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DESIGN · PRODUCTION · MATERIALS

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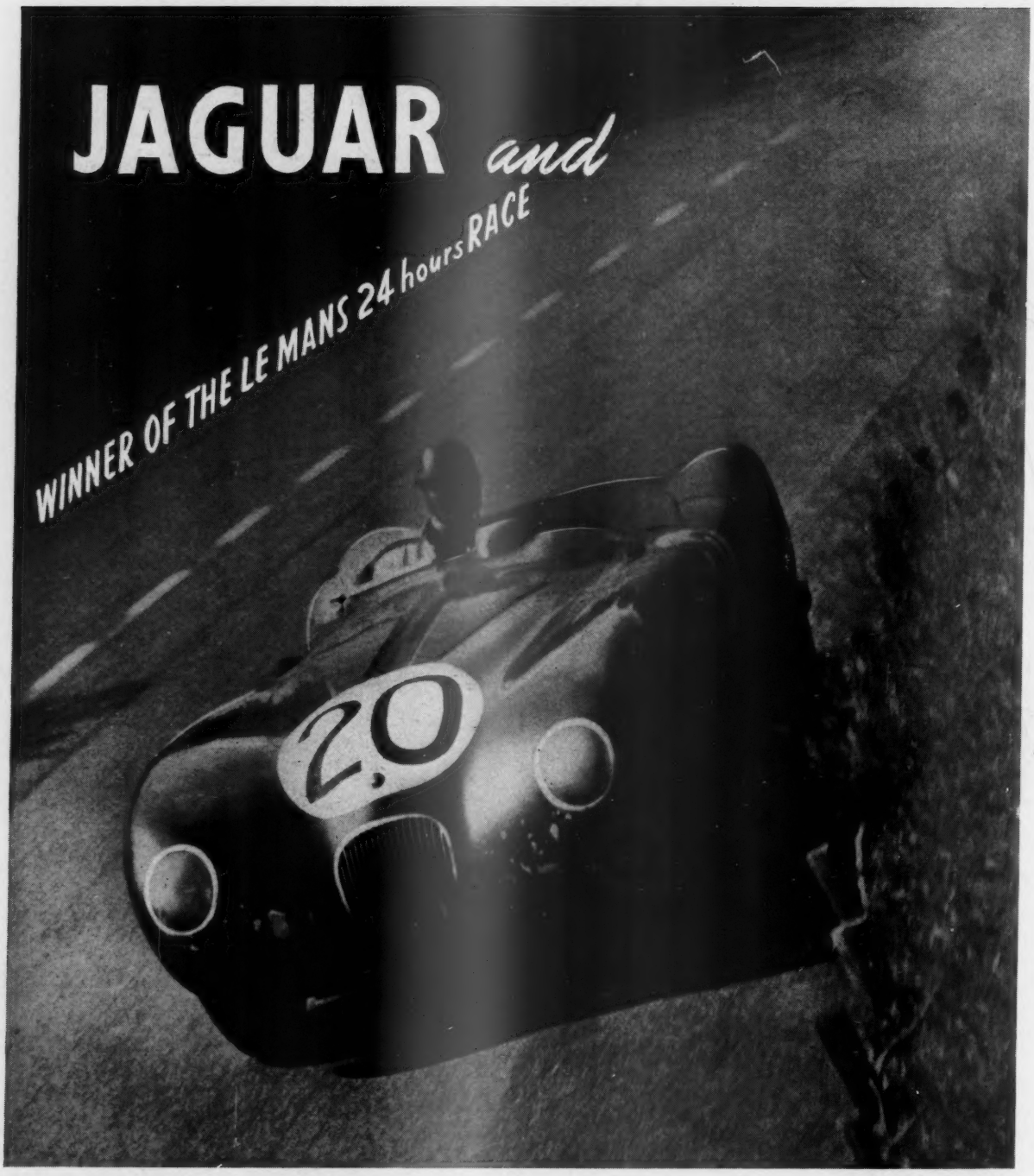

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AUTOMOBILE ENGINEER

Design, Materials, Production Methods, and Works Equipment

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Engine Design

NOT infrequently in engine design the emphasis tends to move from one aspect to another as subsidiary factors assume a temporary significance. These may include, for example, a system of taxation based upon the bore only, or competition regulations framed to encourage development in certain directions. Occasionally such factors tend to obscure the basis of sound design, resulting in a fashion, the influence of which may be felt for possibly a period of years. Provided that a fashion does not seriously violate basic principles, no harm is done. Indeed some exploration of the by-ways from the main trend of development is essential if progress is to continue, since it is by failures that many important lessons are learnt.

An article on the subject of power output in this issue of the *Automobile Engineer* directs attention to one of the fundamental requirements of successful engine design, namely maximum breathing capacity. The power output obtainable from a given engine ultimately depends upon the quantity of air that can be passed through it in a given time, and the efficiency with which that air can be burnt. Obviously, engine breathing and the process of combustion are closely linked, since the turbulence necessary for good combustion is at least initiated during the filling of the cylinder.

While maximum output is by no means the only objective of the engine designer, its development must always be a matter of the greatest technical interest, provided that due regard is paid to overall efficiency and economy of material. In short, there must be a satisfactory balance of the essential factors.

Taking the present Grand Prix racing cars as the highest expression of the art, it will perhaps be agreed that technically the most satisfying solution to the problem set by the formula is the 4½ litre unsupercharged engine, rather than the 1½ litre supercharged engine. There is probably little difference between the weight of these power units but the fuel consumption of the unsupercharged engine is unquestionably lower. Although doubtless the maximum output of the unsupercharged engine is below that of the supercharged 1½ litre, the superior torque of the larger engine at low and medium speeds is apparent. In actual racing conditions there is something approaching a state of equality between the two designs and in the recent British Grand Prix the unsupercharged 4½ litre engine scored its first victory, although on a course that admittedly places a premium on acceleration rather than maximum speed.

If, however, the performance of the 4½ litre unsupercharged engine running on alcohol fuel is compared with the performance of a 500 c.c. racing motor cycle engine running on 80 octane petrol, it is at once evident that there is scope for much development on the multi-cylinder unit. At a conservative estimate the motor cycle engine develops about 50 b.h.p., or 100 b.h.p. per litre. In contrast the unsupercharged 4½ litre engine develops perhaps 360 b.h.p., or 80 b.h.p. per litre. Further, the compression ratio of the 4½ litre engine is presumably substantially higher, since it is running on alcohol fuel.

In general the higher output per litre of a single cylinder engine is, of course, a well known fact and it is largely owing to the excellent breathing and the absence of the distribution problem. From the point of view of mechanical efficiency the advantage should lie with the multi-cylinder engine of the same bore and stroke, but manifold and porting restrictions evidently more than offset this factor.

In the twelve-cylinder 4½ litre engine referred to previously a bore : stroke ratio of 1.08 : 1 is employed and the choice of such "over square" proportions has presumably been made in the interests not only of minimum piston speed at high r.p.m. but also maximum piston area. The shape of the resultant combustion chamber, however, with a domed piston to provide the requisite compression ratio in an approximately hemispherical head, may leave something to be desired from the combustion aspect, while the difficulties of providing adequate cylinder head studding may restrict the space available for ample and suitably contoured porting arrangements.

A combination of these factors may well result in a lower b.m.e.p. than might otherwise be obtained, and the advantage of the large piston area is accordingly offset. It may be questioned, therefore, whether piston area is not being over-emphasized in the present trend of design. Further, the multiplication of cylinders for a given swept volume increases manifolding difficulties and losses in the ports, owing to the increased influence of wall effects.

In aiming for maximum output, therefore, a re-examination of manifolding and porting might well prove of greater advantage than an extension of the maximum piston-area practice, particularly when this is associated with exaggerated bore : stroke ratios.

Although the same conclusions apply broadly to the supercharged engine, since supercharging can only be successfully applied to an engine that is already efficient in the naturally aspirated state, there are other considerations that obscure the main issue. The problem of the supercharged engine is largely bound up with its greater "heat density" and consequent liability to mechanical failure from thermal causes. Thus the case for increasing the number of cylinders is a stronger one, since the greater surface : volume ratio of the smaller cylinders is beneficial from the point of view of piston temperature. Indeed an appreciable reduction in specific fuel consumption may result, bearing in mind that engines of this type rely to a considerable extent on the passage of excess fuel to keep internal temperatures within reasonable limits.

Considerations of this nature tend to divert attention from the fundamentals of engine operation, and from the point of view of real progress of practical and commercial value the continued effort to improve the unsupercharged engine should be encouraged to the full.

Petrol from Coal

TWO months ago, in view of then-impending difficulties in Persia, this journal recalled its consistent advocacy, extending over thirty-three years, of an indigenous fuel industry. It briefly reiterated the sorry record of the fate of praiseworthy attempts in the past to lessen our dependence upon foreign petroleum. Events in the interim have increased rather than allayed concern and invite further comment. There is, perhaps, the possibility of negotiation but even if negotiation is initiated and eventually a patchwork agreement results, can this country rest assured and still continue to neglect development of its own resources? It must be remembered that we already had an agreement with Persia, but what did it avail us? So long as we are completely dependent on foreign supplies, any country producing petroleum, or any through whose territory or seaways the oil has to be transferred, can hold us to ransom in order to enforce economic concessions or even merely to " play politics."

So unsettled and hazardous is the future that the Government has embarked on a rearmament programme of such proportions that the commendable trade recovery has been retarded, the import-export balance drastically upset, and eventually all industry will be affected. It may reasonably be asked, what will be the value of the rearmament if a hold-up of liquid fuel supplies should immobilize it?

It is well to remember that an individual problem, considered without relation to other and contingent problems, is liable to appear of exceptional importance and to be capable of solution. Every Government has to resolve and reconcile the rival claims of many important and divergent problems. What passes comprehension, however, is that the vital question of liquid fuel supplies has for so long been ignored, neglected or even discouraged by all Governments in this country. This is a late hour at which to consider establishing a synthetic fuel industry, but it is never too late to abandon a feckless policy and devote energy to a work of permanent and increasing value and importance.

According to statistics issued by the Petroleum Industry Advisory Committee, the consumption of aviation spirit, motor spirit, kerosene, Derv, gas oil, diesel oil and fuel oil in Britain totalled 4,569,239 tons in 1949 and 5,108,130 tons in 1950. For the same years the amounts of indigenous fuels—motor spirit by low-temperature carbonization, motor and aviation spirit by hydrogenation, and refined benzole, but not including shale and native crude oil—made available for use in Britain were 383,558 tons and 319,968 tons respectively. That is progression backwards. In the face of this, the prodigious export of benzole may well be considered. In the January-March quarter of 1950 we sent abroad only 3,691 gallons, but during the same period of 1951 we sent 8,509,360 gallons. That is indeed The Rake's Progress.

By contrast consider America, possessing vast petroleum resources. In 1944 the U.S. Congress voted $60 million for development of a synthetic fuel programme up to 1952. Last year the term was extended to 1955 and an additional $26 million was authorized. This year the U.S. Government has made an urgent appeal to private enterprise to establish a synthetic fuels industry based on coal and shale, and generous financial assistance is offered.

In South Africa an American concern, the M.W. Kellogg Co., of New York, is building an oil-from-coal plant for the Union Government at Coalbrook, Orange Free State. The cost will be about £18 million and the initial production of petrol, scheduled for 1954-1955, will be at the rate of 60 million gallons per annum.

Britain's need for liquid fuels from native resources is vital. The hackneyed excuses of shortages of money, of material, and of labour are not good enough. All these prerequisites can be found for festivals, fun-fairs and other frivolities. If we may paraphrase the slogan which gained currency before the war, we suggest—"Synthetic fuels are better than synthetic amusements."

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POWER OUTPUT

An Account of the Work of the Weslake Laboratories

GIVEN a combustion chamber designed on modern principles, then for a given type of camshaft, valve gear, and compression ratio, the power developed will be in direct proportion to the engine's breathing capacity. While breathing capacity is in a sense an integral part of a combustion chamber design, very great importance attaches to the porting, both before, during, and after transfer. The dominant influence of this aspect of engine design and the critical effect of filling on engine performance was fully appreciated by Mr. Henry Weslake even in the very early days of engine development. Remarkable results were in fact secured by attention to porting, even when knowledge of combustion chamber design and valve layout and disposition was at a relatively elementary stage.

In many cases, outstanding results were achieved without any alteration to chamber and valve gear designs that were, to say the least, primitive. In the passing of the years great advances have been evidenced in knowledge of the combustion process, and also to a lesser degree in valves and valve gear. These advances, in conjunction with greatly increased knowledge of ultra high speed air flow principles, both into and out of the engine, have made possible the really remarkable results now secured from engines fitted with heads of Weslake design.

By working on this basic principle a system has been developed by which outstanding powers are achieved without any apparent penalty, and employing normal compression ratios, moderate lifts and orthodox profiles. Further, the desired outputs have been forthcoming without sacrifice of engine docility. All the stress, vibration, and uncertainty associated with extensive lap and lead, excessive lifts and highly stressed components generally are unnecessary. Weslake engines are in fact, despite their phenomenal output, as quiet and manageable as a low output design. Idling is steady, the opening up certain and powerful despite the especial responsiveness and power. Neither are these results obtained by flooding the engine with fuel. All Weslake engines are notable for their economy in consumption, and are generally knock free.

In general an immense amount of effort has been directed towards a fuller understanding of the phenomena of combustion in the internal combustion engine. Nevertheless, it is probably true to say that in relation to car design no other subject is still open to so much fundamental discussion. The fact that even now a satisfactory means of direct study of the combustion process has yet to be devised, leaves much that can only be inferred by deduction and indirect examination. There are accordingly differences of opinion on many points of detail.

From the practical point of view, however, three characteristics of an automobile engine are of prime importance, namely specific output in terms of horse-power per cubic inch displacement, specific fuel consumption, and ability to make the maximum use of available fuel from the point of view of its anti-knock value. Basically, the internal combustion engine is simply a device for burning air, and its output is dependent upon the flow of air through it and the utilization of the air in the combustion chamber. These two fundamental factors are interrelated, and they have for many years constituted the special study of the laboratories of Weslake & Co. Ltd., Harbour Road, Rye Harbour, Sussex.

Historical

Mr. Weslake's interest in the subject actually originated in 1923 when three apparently identical Sunbeam motor cycle engines of 500 c.c. swept volume gave outputs of 26, 27.5 and 29 b.h.p. Detailed examination of the engines showed no reason for variations in mechanical efficiency, and it was not until the cylinders and cylinder heads had been flow tested that variations in air flow of 10 per cent. to 15 per cent. were found. Adjustments to the port shapes corrected these discrepancies. The use of wooden models, permitting easy modifications to be made during flow testing on the rig, is derived from this experience. This technique is still the basis of the work of the Laboratory.

Subsequently, motor cycles embodying Weslake modifications in the engines secured many world records at Brooklands. During this period the Wex carburettor was developed. This embodied a fan-shaped diffuser having a wide slot through which the fuel issued. Even in its most elaborate form, with pilot diffuser, air bleeds, and capacity well for acceleration, it was an extremely simple device and is in fact still used for single cylinder research work.

As consultant to the original Bentley Company

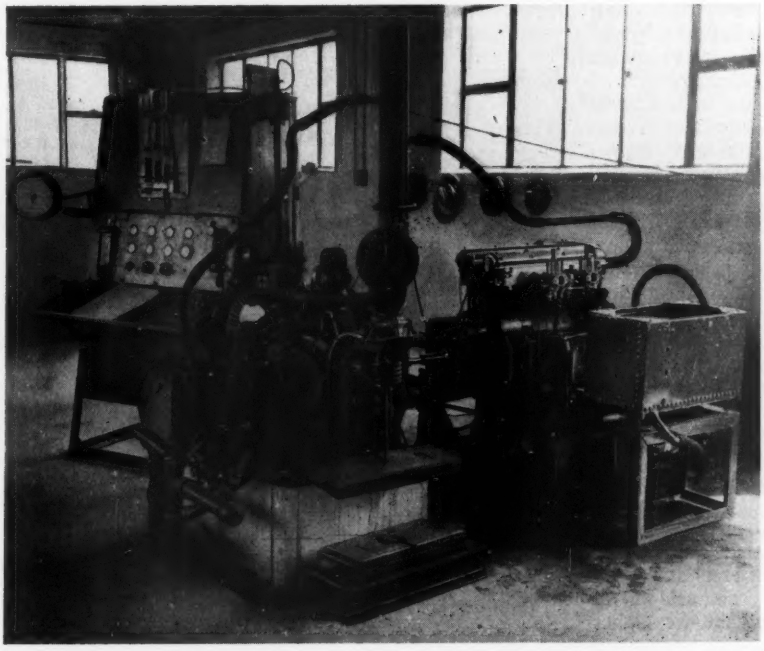


Fig. 1. Typical test set-up on Heenan and Froude water brake

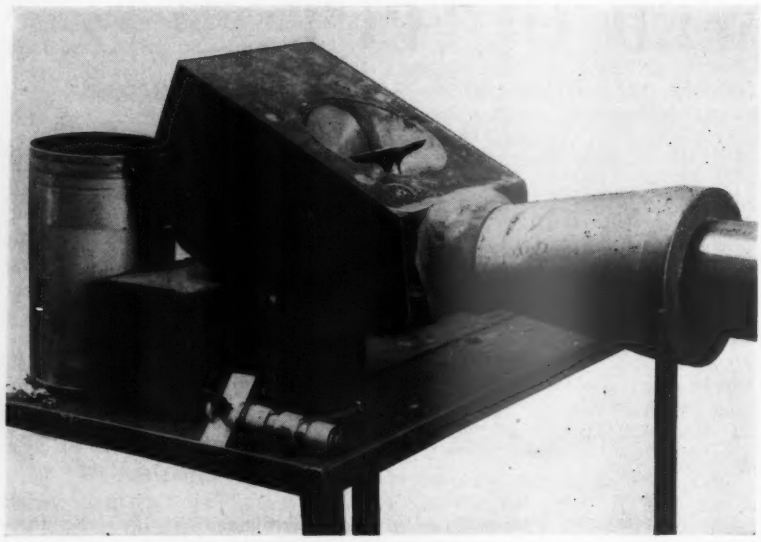


Fig. 2. Wooden model on air flow test

Mr. Weslake was concerned in air flow work on their six-cylinder engine, resulting in the development of the Speed Six that won at Le Mans in 1929 and 1930. Later he was concerned in the development of the Coventry Climax engine with overhead inlet valve and side exhaust valve as used in Triumph and Crossley cars, the Jaguar push-rod o.h.v. range and the Armstrong-Siddeley 2-litre engines. On some of these later examples gallery induction systems were embodied. Among recent developments is the "three-zone" port, as embodied in certain outstanding cars of today. It is employed in association with vertical valves in the Austin range of cars that has established a very high standard of performance.

Among cars of the highest performance the three-zone port is employed in conjunction with hemispherical combustion chambers and valves operated by twin overhead camshafts, on the Jaguar XK 120 sports car and the Mk VII saloon. The outstanding performance of this engine is acknowledged throughout the world, and the success of the Jaguar XK 120 C in winning the recent Grand Prix d'Endurance at Le Mans has provided the most convincing proof of the supremacy of the British sports car. From the very beginning these machines dominated the race, notwithstanding the opposition of 4½ and 5½ litre cars of Continental and American origin. It is significant also that this 3½ litre engine is notable for smoothness and flexibility, qualities that seldom accompany performance of the highest order.

The achievements are the outcome of many years' intensive study of air flow through the engine from the air cleaner to the end of the exhaust pipe, and are founded on essentially simple and logical reasoning. Further, the Laboratories house the minimum of complex equipment, and the small staff are accordingly able to concentrate on the problem in hand rather than on the needs of delicate and sometimes unreliable instrumentation. Not surprisingly, much of the success of the Company springs from its very compact organization, which makes for maximum co-operation under forceful leadership. Business management, a matter presenting some unusual problems in an enterprise of this nature, is in the hands of Mrs. Weslake.

Laboratory equipment

As indicated earlier, the basic technique of the laboratory is the testing of wooden models (Fig. 2) on one of the two air flow rigs. Following the layout of the design in the drawing office, a wooden model is made and flow tested, modifications to port shape, valve guide bosses, etc. being progressively made by cutting away material or building up with plasticene as necessary. The final design can then be made in the drawing office, plaster casts from the wooden model being occasionally employed to assist the foundry.

A "gas holder" type of rig is generally used for this work, the air flow being the time elapsed for a given volume of air to pass through the model. The actual volume is varied according to the size of the model and is chosen to give not more than a 2 per cent. error. Turbulence in the model cylinder is measured by means of a swirl meter. For tests requiring a longer duration of air flow a blower rig is used. Air flow is measured by Rotameter and orifice plate.

Engine testing is carried out exclusively on Heenan and Froude water brakes (Fig. 1), since these have been found entirely reliable, particularly from the point of view of the reproducibility of results. Their capacity ranges from 700 b.h.p. to 60 b.h.p. Two of the smallest type DPX1 brakes are mounted in tandem (Fig. 3). One is coupled to a 600 c.c. single cylinder research unit which normally runs naturally aspirated. Motoring

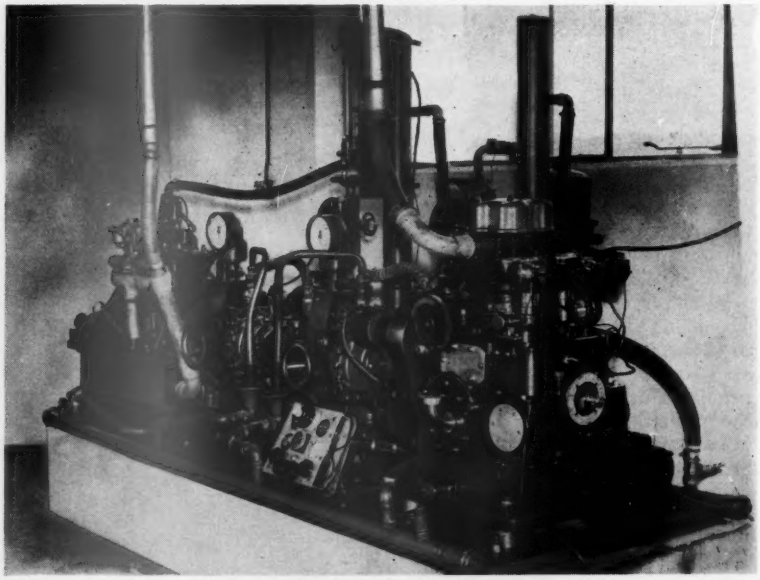


Fig. 3. Single-cylinder research unit with DPXI brakes

facilities are afforded by a calibrated engine attached to the rear end of the second brake as shown in Fig. 3. This engine is also used to drive the supercharger. The second brake, however, can be connected to the single cylinder engine when it is desired to run this engine supercharged. This engine has variable compression ratio and valve timing, and all auxiliaries except the distributors are separately driven. Some variation in bore size is permitted by the use of wet liners. The stroke is 113 mm. An interesting detail is the use of a Wills joint ring in place of the normal gasket. Beyond the normal test house equipment of fuel flow meters, etc. there is no more elaborate equipment in daily use than a stroboscope for accurate measurement of ignition timing, although specialized equipment has been evolved to deal with more abstruse problems.

Engine performance

Compression pressure is used as a basis for comparison between successive modifications to a given engine. In general, however, Fig. 4 shows the limitations on breathing imposed by valve location. It presupposes a common denominator of design skill, so to speak, as regards port and manifold design, and demonstrates the superiority of the hemispherical head at the higher speeds.

Fig. 5 shows the effect of siamesed inlet ports on a four-cylinder engine. Since at one period of the cycle both valves fed from each port overlap, one cylinder always robs its fellow of a full charge. Further, the discharge rate of a siamesed port falls more rapidly with increasing speed than that of a single port. In the example given this effect can be observed, apart from the higher compression pressures that the single port provides throughout the speed range. The engine concerned is of just over 2 litres swept volume and has a compression ratio of 6.75 to 1. The 42 mm. carburettor has a 31 mm. choke. Similar results are

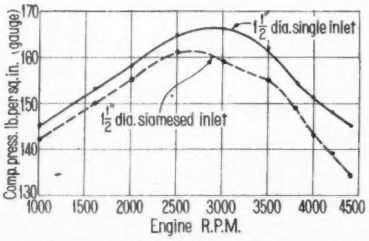


Fig. 5. The effect of siamesed inlet ports

found in the case of six-cylinder engines with two single and two siamesed ports.

Much the same reasoning applies to the exhaust ports. Not only is the valve temperature higher in a siamesed port, but every effort must be made to impart the maximum kinetic energy to the outgoing gas, right up to the exhaust valve closing point, to ensure good scavenging. The six-cylinder engine is a good example, and to avoid two valves opening simultaneously into the manifold it requires a divided exhaust system. A divided manifold only is not enough if the maximum advantage is to be obtained from the energy of the exhaust gases. This modification alone has been known to increase the output of an engine from 88 b.h.p. to 106 b.h.p.

Port design

In Fig. 6 is shown the three-zone inlet port. Zone 1, the entry to the port from the manifold, tapers to the throat diameter which is the smallest cross-sectional area in the port. Not only does the taper decrease the contraction effect of the change in section from manifold to port, but the venturi effect of the whole port results in a pressure build up behind the valve head. Zone two is proportioned to minimize the obstruction of the valve stem and may also be used to influence turbulence by providing a directional swirl in certain designs. The third zone is the valve seat with a radiused entry to the seat proper. This in combination with the valve shape is designed to provide the highest possible flow at low lift. Seat angle also influences flow, and provided that the general layout of the combustion chamber allows the air flow to be maintained parallel with the seat angle, a 30 deg. seat gives better flow at part lift.

The exhaust port (Fig. 7) is proportioned to give the same flow on the rig as the inlet port, and broadly speaking is designed on the same principles. The valve may be regarded as located at the throat of the venturi, and it has been found that in the long, divergent port a substantial valve guide boss can be provided without loss of flow. This is presumably owing to the reduction of eddying behind the valve head, and it also gives the maximum scope for good cooling arrangements of the guide. The valve head is slightly sunk to eliminate scrubbing by the fresh charge.

Owing to the higher wedging and self-cleaning action, a 45 deg. seat is used. Further, there is less contraction of area of the gas stream than with a 30 deg. seat, particularly in designs where the combustion chamber allows little clearance around the valve head.

Combustion chambers

As already indicated, the hemispherical head is regarded as the ideal from the point of view of maximum output. Fig. 8 is an example of the results that can be attained. It can also burn lean mixtures provided that a moderate degree of turbulence is allowed. This can be adjusted by attention to the radius and offset of the port, as shown in Fig. 9. The combustion chamber shown in Fig. 10 has been designed for engines having vertical overhead valves. A feature of this chamber is the peak A projecting between the exhaust valve seat B and inlet valve seat C, that not only controls the degree of turbulence but also deflects the incoming charge away from the hot exhaust valve. Additional control of turbulence may be obtained

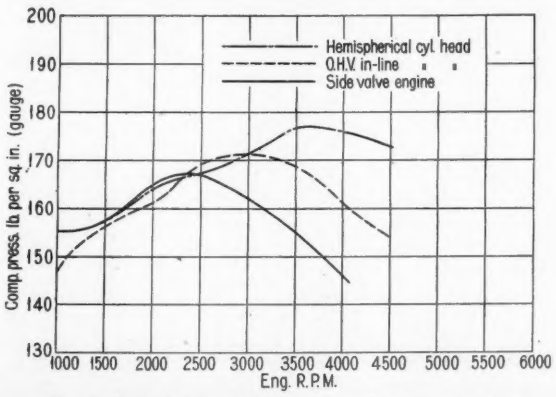


Fig. 4. Typical compression pressures for various engines

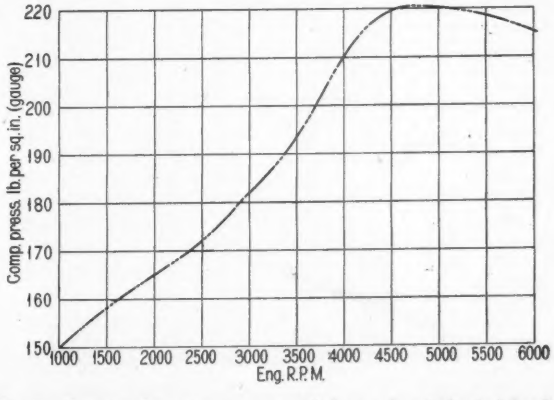


Fig. 8. Compression pressures recorded on a hemispherical head

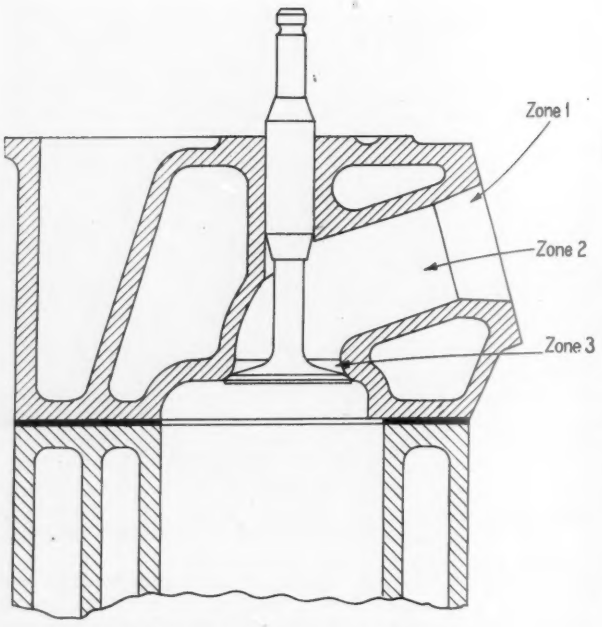


Fig. 6. Elements of the three-zone inlet port

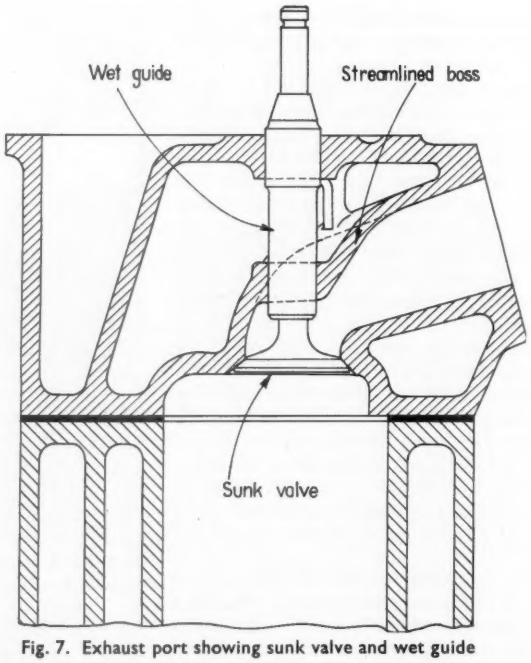


Fig. 7. Exhaust port showing sunk valve and wet guide

by bias of the port or by the use of a concave piston crown.

The wall of the chamber is undercut adjacent to the inlet valve seat, as shown at D, while a lip E diverts the charge across the chamber, rather than permitting it to escape down the cylinder bore. By this means a measure of stratification is obtained, the fuel being projected across the chamber towards the sparking plug F. The plug is positioned so that turbulence tends to sling the fuel into the socket, thereby ensuring a rich mixture at the plug, and a weak end-gas. The plug position is selected to ensure smooth combustion and good part load performance. It has been found that the plug position giving the best performance at full load will not burn lean mixtures under light load. The plug position is chosen to suit the low load factor at which the automobile engine customarily operates.

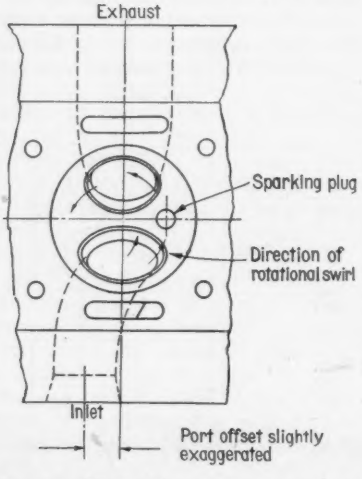


Fig. 9. Offset inlet port to promote turbulence

General

Cold starting and the warm up period cannot yet be regarded as satisfactory. In general, their requirements conflict with the mixture conditions desirable for maximum output. Further, the need for up to 10 deg. more ignition advance with a cold engine renders the selection of the optimum advance range a matter of difficulty. It is considered that a water jacketed manifold provides the best compromise, since temperature variations and therefore ignition variation requirements are reduced to a minimum. Ideally, a variable datum advance, sensitive to charge temperature, is desirable.

On the question of low speed pulling as affected by distribution, it is felt that too much attention has been paid to improvement by the process of reducing choke size and increasing hot spotting. Much remains to be done by improved induction pipe design and attention to the influence of the carburettor itself on distribution. Good filling is essential for low speed pulling, and with correct port design the use of exaggerated overlaps to obtain high speed performance at the expense of good filling in the lower speed range is unnecessary.

Some scepticism is felt about the current trend in the U.S.A. towards the use of high compression ratios to obtain economy. Bearing in mind that the load factor of an automobile engine is generally low, a substantial increase in compression ratio is necessary to show any appreciable improvement in specific fuel consumption at, say, $\frac{1}{4}$ load. It is felt that rather than increase engine scantlings to withstand the higher pressures, and also risking an increase in knock sensitivity, ignition sensitivity and sensitivity to engine fouling, the search for further economy should still be concentrated on "burnability" of weak mixtures. It is also suggested that too high a compression ratio for a given fuel may result in the loss of effective ignition advance in order to render the engine knock free. Consequently the specific fuel consumption may suffer compared with the same engine using a lower compression ratio and optimum ignition advance.

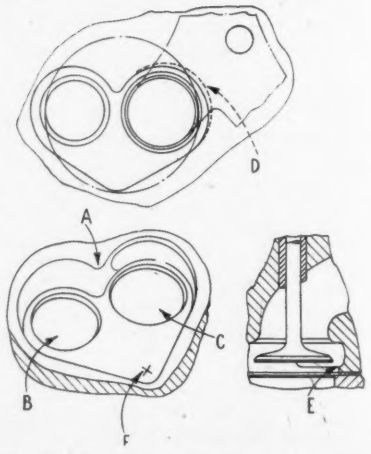


Fig. 10. Combustion chamber with vertical valves

ENGINE DETAIL MACHINING

Production Methods for Ford Consul and Zephyr Connecting Rods and Crankshafts

IN the production of crankshafts and connecting rods it is not feasible to employ such spectacular machine developments as those now used by the Ford Motor Co., Ltd., Dagenham, for machining the cylinder blocks for Consul and Zephyr engines. Nevertheless, the methods that are employed for the crankshafts and connecting rods of these engines are of considerable interest, inasmuch as they have been planned to produce components of great accuracy in a shorter time and with less labour than was possible with the machines and methods hitherto employed.

Crankshaft machining

There are two parallel and adjacent lines for dealing with crankshafts. In the main, one line is tooled for dealing with shafts for the Zephyr six-cylinder engine and the other for shafts for the four-cylinder Consul engine. Certain machines of high output capacity are arranged to deal with either type of shaft as necessary and at some operations the machines are so arranged that both types can be machined simultaneously. These notes will describe the six-cylinder line in detail. In general, the machining sequences are the same for both shafts. There is, in fact, only one major difference. This will be discussed later.

Cast shafts are fitted in both engines. They are produced in the Company's foundry and before they are delivered to the machining section they are heat-treated for stress relieving and to produce a specified Brinell hardness. As it is received from the foundry each shaft is checked for alignment and straightness before any machining is carried out. The first machining operation is carried out in a Hey No. 3 automatic horizontal centring machine. Location for height is taken from the pins and longitudinal location from the width of the thrust bearing. On this machine the pulley end is centred and faced while the flange end is centred only.

Until quite late in the operation sequence when there are accurately ground bearings and pins to serve as location surfaces, these centres locate the shaft for most operations. They do not, however, give in themselves sufficient location for the first main operation, the third in the machining sequence, when all main bearings and the flange and pulley ends are machined simultaneously in a Le Blond automatic centre drive crankshaft lathe. Extremely heavy cuts are taken in this machine and both to prevent deflection of the shaft under the cutting load and to provide accurate location in the centre drive chuck, two pads on the centre balance weight are ground to a close tolerance. These pads are ground on a Precimax plain cylindrical grinder and since the shaft is carried on the centres they are ground in true relation to the centres.

The Le Blond automatic centre drive crankshaft lathe, see Fig. 1, has proved to be a most important development in speeding up the production of crankshafts. It allows rough, semi-finish and finish machining operations to be carried out on all the main bearings and all other surface concentric with the shaft axis at a single setting. Roughing and semi-finishing are effected by the same sets of tools which are mounted on two sets of slides. The finishing tools are carried in a trunnion mounted cradle which pivots to bring the tools to the cutting position and at the completion of the cut, pivots back to give easy access for loading and unloading.

Roughing and semi-finishing operations are carried out from four pairs of tool slides, one pair for the flange end and rear main bearing, one pair each for the intermediate bearings, and one pair for the front main bearing and the pulley end of the shaft. Only simple tooling is called for on the intermediate bearings. For each of these the leading tool slide carries a turning tool that is slightly less in width than the length of the bearing and the second slide carries two tools for machining the fillet and facing the cheeks.

Complicated tooling is necessary on the other slides. At the machining operations for the front end of the shaft, No. 1 main bearing and the pulley end of the shaft are rough and semi-finish turned to diameter, the fillet and the web cheek are machined and a chamfer is formed at the front end of the bearing. At the same time the end of the shaft is chamfered, a locating face for the pulley is machined and a radius is formed from this face to the front end of the bearing. The leading slide carries two tools, one for machining the bearing diameter and the other for machining part of the length of the pulley end to semi-finished diameter and for chamfering the end of the shaft. Two form tools are mounted on the second slide. One turns the fillet from the bearing to the web, the other turns the remainder of

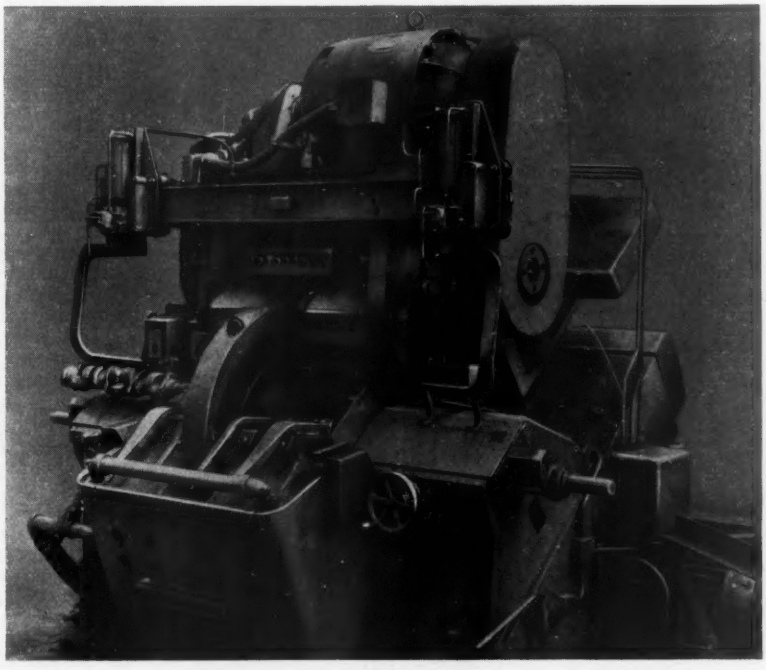


Fig. 1. Le Blond centre drive crankshaft lathe used on Ford Zephyr crankshafts.

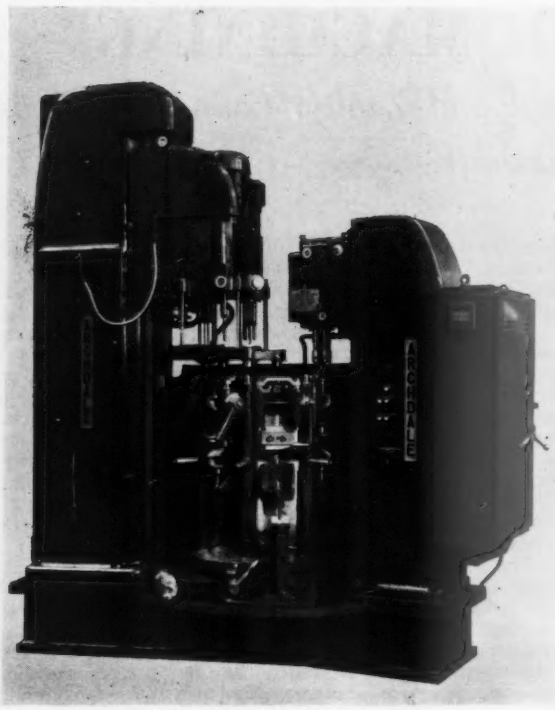


Fig. 2 Archdale special purpose drilling, reaming and tapping machine.

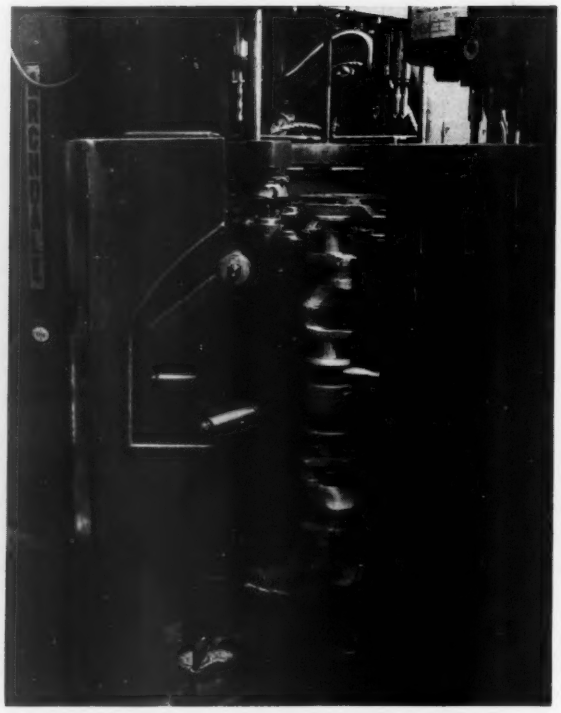


Fig. 3. The loading station for the Archdale machine illustrated in Fig. 2

the pulley end, machines two faces and forms a chamfer on the front end of the bearing.

Two tools are mounted in the leading slide and four in the second slide. One tool in the leading slide machines the rear main bearing diameter while the other forms the oil slinger groove and turns the O.D. of the flange. Of the tools in the second slide, one machines the fillet to the web, the second faces the flange between the bearing and the oil slinger groove and also turns the O.D. of this flange; the third chamfers both sides of the shaft flange and the fourth faces the outside face of the flange.

High speed tools are used at a cutting speed of 41 ft/min. Roughing and semi-finishing cuts are effected by the same tools. After the fast approach stroke of the slides, a feed rate of 0·030 in. is applied for roughing, and at a predetermined point in the tool advance it is reduced to 0·010 in. for the semi-finishing cuts.

As was stated earlier, finishing is effected by tools mounted in the cradle of the machine. For the intermediate bearings a single tool at each tool station serves to finish the bearing for diameter and width, but complicated tooling is once again necessary at the end stations. For the front end of the shaft two tools are mounted in a single holder. One finishes the diameter of the pulley end, machines an undercut, machines the locating face for the pulley and a radius from this face to the front end of the main bearing. The other tool finish machines the bearing diameter and the fillet to the web.

Three tools are mounted in the tool holder from which the flange end and the rear main bearing are finished. One, a plain turning tool finish machines the bearing for diameter and width. A form tool finishes the O.D. of the oil slinger flange, the oil slinger groove form, the O.D. of the flange and the chamfer on the outside face of the flange. The third tool finish machines the outer face of the flange. The cutting speed is the same as for roughing and semi-finishing but feed rate for finishing cuts is reduced to 0·005 in. In addition, there is a sizing dwell of preset duration for sizing the work. The floor-to-floor time is four minutes.

Fig. 4. Landis multi-wheel grinder tooled for semi-finish grinding four main bearings and the O.D. of the flange

This machine is so designed that the centre drive ring gears always stop in a predetermined position to facilitate loading and unloading. Further, to facilitate loading and unloading there are travelling hooks mounted at either side of the machine. These hooks are inter-connected with the machine controls in such a manner that the machine cannot be started until each hook is in its outermost position. In loading the machine, location to the axis of the shaft is taken from the centres and the ground pads on the centre balance weight. Longitudinal location is taken from the width of the thrust bearing. Incidentally, as a further precaution against inadvertent damage to the machine, the chuck wrench must be removed from the machine and placed in a holder before the machine can be started. This holder pivots under the weight of the wrench and thereby actuates an interlocking switch.

From the Le Blond machine the shaft is transferred to a Churchill plain grinder on which the width of the thrust bearing is ground to a tolerance of 0·002 in. All length dimensions on the shaft are referred in some way to the thrust bearing. This operation is, therefore carried out to provide accurate locations for subsequent operations.

Pollard vertical drilling machines are used for the next three operations. On the first, a tapping hole is drilled in the pulley end; on the second the pulley end is faced to length and recentred; and on the third, the flange end is recentred and a hole is drilled and counterbored. The only point of interest in these operations is that the fixtures are designed to take shafts for both four and six-cylinder engine crankshafts since these three machines have sufficient output capacity to cope with the production from both lines.

An Archdale special purpose vertical drilling and tapping machine, illustrated in Figs. 2 and 3, is used at the next operation. It is tooled for drilling, countersinking and tapping four holes and for drilling, countersinking and reaming a dowel hole in the flange. As this machine also has output capacity that is able to maintain the desired production for both lines, the six-station indexing work fixture is designed to take both four and six throw shafts. In fact it is possible to deal with both types simultaneously. Location is taken from the centres in the shaft ends and from the webs of the thrust bearing. To change a station from one type of shaft to the other, it is merely necessary to move up or down a bracket carrying the locating centre for the pulley end. The centre for the flange end of the shaft is carried in a bridge piece that can be raised and lowered through rack and pinion movements operated by simple movement of a lever. This allows the bridge piece and locating centre to be lifted sufficiently to allow the shaft to be loaded into position. The bridge piece is then lowered to locate and clamp the work.

For drilling, countersinking and reaming, the machine incorporates a unit construction, hydraulic feed drill head of the fixed centre type and a lifting type drill bush plate that locates in the fixture. The tapping head has an independent lead screw and a safety tapping chuck on each spindle. All the spindles have independent end adjustment so that there is no need to grind the tools in sets to a specified length. The machine itself has a fully automatic cycle, but the fixture is indexed manually. Provision is made to ensure that if the fixture is not correctly indexed, the machine is inoperable.

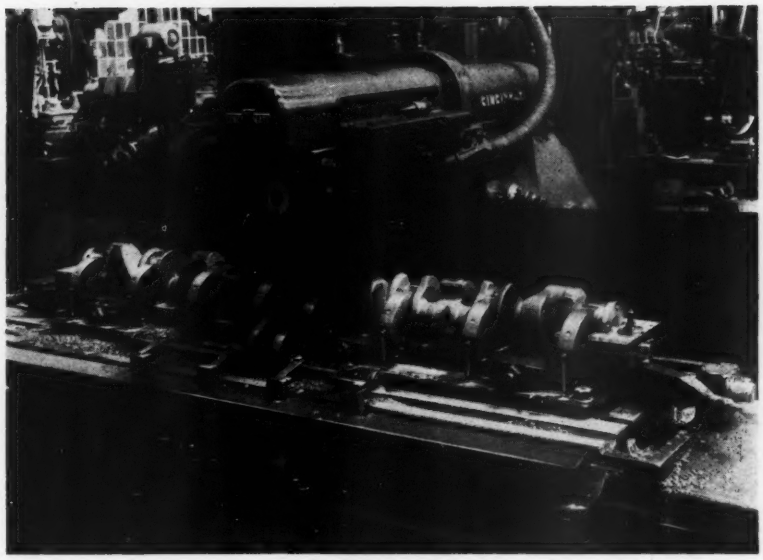


Fig. 5. Cincinnati servo miller tooled for machining the driving pads on four-throw and six-throw crankshafts.

From the Archdale machine, the shaft is transferred to the Landis multi-wheel cylindrical grinding machine shown in Fig. 4. This machine carries five grinding wheels, four for semi-finish grinding the main bearing diameters and one for semi-finish grinding the O.D. of the flange. On the Le Blond centre drive crankshaft lathe the bearings were machined to 2·280/2·285 in. diameter and on the Landis machine they are ground to 2·259/2·260 in. diameter. The shaft is mounted in centres. Longitiudinal location is taken from the ground faces of the thrust bearing. A dial indicator built into the grinding head of the machine allows this location to be quickly and accurately determined. The work rotates at 70 r.p.m. and grinding is effected by 467R Aloxite wheels running at a peripheral speed of 6,000 ft. per

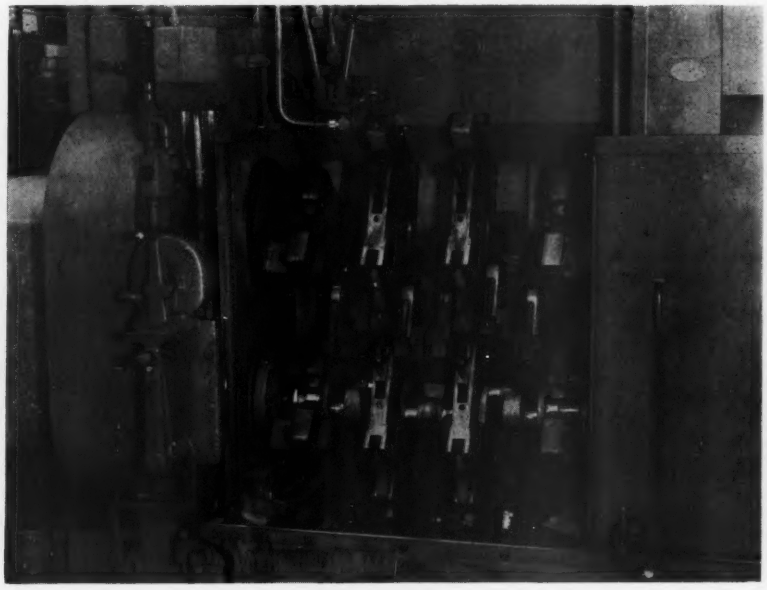


Fig. 6. Le Blond two spindle crankpin lathe.

Fig. 7. Cross special double-end drilling machine for drilling the lightening holes in Ford Zephyr crankshafts.

minute. Directly opposite each of the wheels for grinding the main bearings, there is a steady that is hydraulically and automatically adjusted as grinding proceeds. The machine also incorporates a special wheel dressing attachment.

A Cincinnati horizontal milling machine, illustrated in Fig. 5, is used at the next operation to mill driving pads on the webs of Nos. 1 and 6 bearings. These pads have no functional purpose other than to take up the drive at the pin turning and subsequent operations. Galtona cutters running at 60 ft. per minute cutting speed and 0·009 in. tooth load are used and the output capacity from the machine is sufficient to meet the requirements for both types of crankshafts. Two fixtures giving location from the ground main bearings and the dowel hole in the flange are mounted on the machine table. Either type of shaft can be mounted in either fixture and as may be seen from Fig. 5, it is possible to use one for four-throw and the other for six-throw shafts. The change-over from one type of shaft to another is effected by automatic adjustment of the trips for operating the servo mechanism.

After the driving pads have been milled the shaft is transferred to a 6AC Le Blond two-spindle crankpin turning lathe, see Fig. 6. This, like the Le Blond lathe used for turning the main bearings, is designed to give high rates of stock removal and high output. Two shafts are machined simultaneously. Each shaft is mounted in two hydraulically operated pot chucks and drive is from both ends. Endwise location is taken from the face of the rear intermediate bearing.

On this machine there are two tool slides at each station, one carrying the turning tool for the diameter and the other carrying two tools for machining the cheeks to width. Two master crankshafts, enlarged copies of the shafts to be machined, control the movement of the tools through the cycle of rapid traverse to start of cut, roughing feed at 0·020 in. semi-finishing feed at 0·010 in., finishing feed at 0·005 in. and rapid return to the starting position. High speed steel tools are used at a cutting speed of 33 ft. per minute. The specified tolerances are 0·003 in. on diameter and 0·005 in. on width. A good quality of finish from this machine is essential, since there is only one grinding operation to follow. The floor-to-floor time is 14·0 minutes and as two shafts are machined simultaneously the output at 100 per cent. efficiency is 30 shafts per hour.

A Cross special double-ended horizontal drilling machine is used for the next operation on the six-throw shafts. It is shown in Fig. 7, and is used for drilling a $\frac{3}{4}$ in. diameter lightening hole in each pin bearing. There are three independent drilling heads at each end of the machine, each set to the appropriate angle. These holes must be accurately positioned and the fixture is so arranged that location is taken from the semi-finish ground main bearings and the turned pin bearings. Three holes are drilled from one end of the machine, and when the drills have been retracted, the fixture, and with it the shaft, is shuttled into position for drilling from the other end.

At this stage the oil holes are drilled from the main bearings to the pins. These holes are drilled on three Leland Gifford two-spindle reciprocating deep drilling machines. The first machine drills the holes from the rear main bearing to No. 6 pin and from the front main bearing to No. 1 pin; the second drills from the rear intermediate main bearing to No. 4 pin and from the front intermediate main bearing to No. 3 pin; and finally the oil holes are

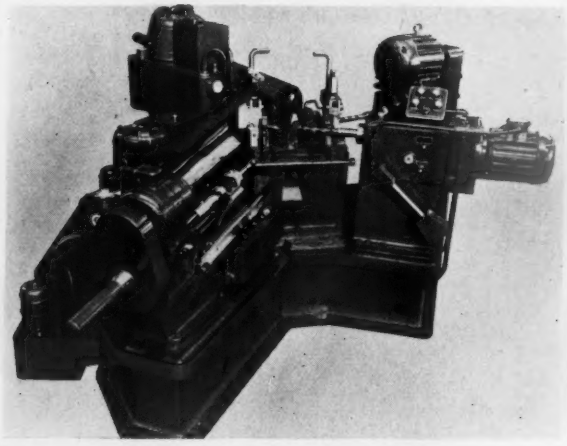


Fig. 8. Special purpose Archdale machine for drilling lightening holes and oil holes in Ford Consul crankshafts.

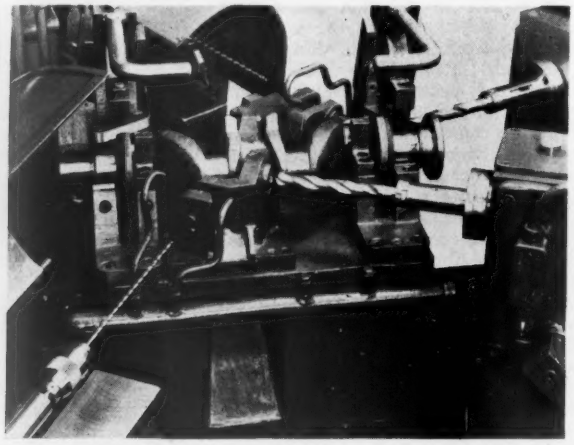


Fig. 9. The tooling on the machine shown in Fig. 8. Two of these machines are required to complete the operation.

drilled from No. 5 pin to the rear intermediate main bearing and from No. 3 pin to the front intermediate main bearing. These holes must also be very accurately positioned to ensure that there is no danger of their breaking into the previously drilled lightening holes. In every case, location is taken from the main bearings and the pins.

Different machines and methods are used for drilling the lightening holes and oil holes in the four-throw crankshafts. For these shafts two special Archdale machines, see Figs. 8 and 9, are used. Each machine combines two heads for drilling lightening holes and two for drilling oil holes. Automatic cam-feed, size 1A unit drilling heads are used for drilling the lightening holes. One revolution of the cam gives quick approach, feed and quick return. The motor is plug stopped at the end of the return stroke. Standard reciprocating-feed, deep drilling units are used for drilling the oil holes. To allow the fastest possible machining these units have a mechanical trip for the change from fast traverse to feed rate.

There are several interesting features incorporated in the work fixture. As is customary with fixtures designed by J. Archdale and Co., Ltd., for deep hole drilling applications, there are two drill bushes for each oil hole drill. At every withdrawal the drill is drawn clear of the first, but is still supported in the second so that there is no danger that the long and slender drill will whip. The end of the drill bushes adjacent to the work is radiused so that the bush can be brought practically into contact with the surface to be drilled. One of the oil holes drilled on each machine is drilled from above the centre of the shaft and it has therefore been necessary to arrange that the guide bush plate can be moved out to allow loading and unloading. This moving guide bush plate is connected with one of the clamps in such a manner that when the clamp is applied the bush plate is at the same time moved into the drilling position, and when the clamp is released the bush plate is moved away from the work. Furthermore, because of the restricted space, the guide bush for one of the lightening hole drills is in the base of one of the clamping fixtures.

The only grinding operation on the pins is carried out on a Norton Crankomatic grinder immediately after the oil holes have been drilled. The set-up on this machine is shown in Fig. 10. At a previous operation the pins were machined to 1·298/1·301 in. width and 1·967/1·972 in. for diameter. They are now ground to 1·319/1·321 in. width and 1·9367/1·9371 in. diameter. A 42 in. Aloxite wheel running at 7,000 ft. per minute peripheral speed is used. The specified surface finish from this operation is 15–20 microinches. The machine incorporates a cut-out device which automatically gives a predetermined sizing dwell when the correct diameter is reached and then automatically causes the wheel to retract.

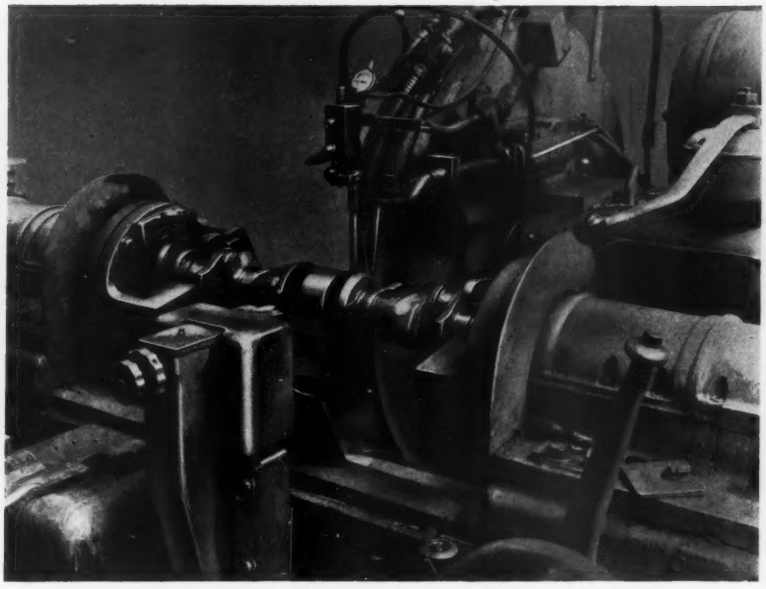


Fig. 10. Grinding the crankpins on a Norton Crankomatic machine.

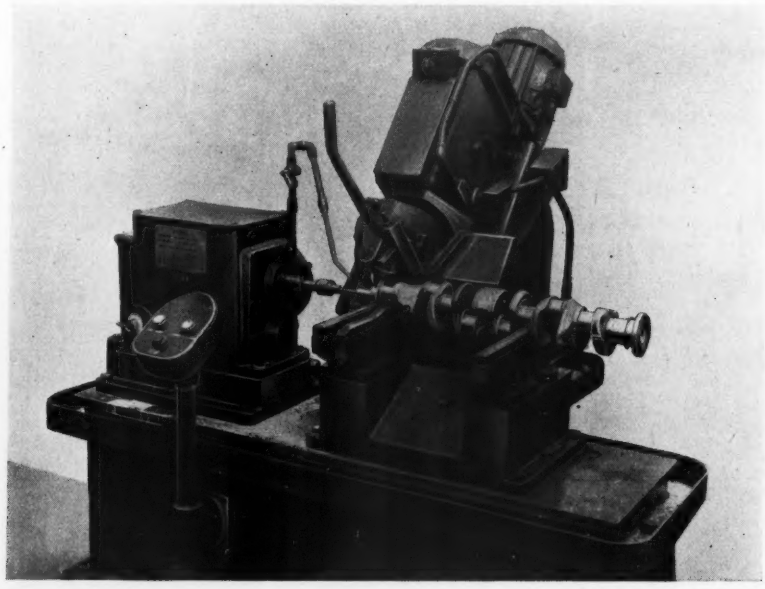


Fig. 11. An Archdale combined milling and tapping machine used on both Zephyr and Consul crankshafts.

Three machines are used for finish grinding the four main bearings. Three machines are necessary since plunge grinding is employed and there are three widths of bearings. On the first machine, a Precimax plain cylindrical grinder, two intermediate main bearings are ground. The front and rear main bearings are ground on Newall plain grinding machines. At an earlier stage in the operation sequence these bearings were semi-finish ground to 2·259/2·260 in. diameter and the finishing operation reduces the diameter to 2·2502/2·2506 in. Once again a finish of 15/20 microinches is specified.

Further grinding operations are then carried out. At the first, a Churchill plain cylindrical grinder with a formed wheel is used for grinding two adjacent diameters, one to take the pulley and the other to take the timing gear. A Churchill angle wheelhead grinder is then used for grinding the back face of the flange in relation to the face of the oil slinger and at the same setting the O.D. of the flange is ground to a 0·001 in. tolerance. To complete the grinding operations a Precimax plain cylindrical grinder with a formed wheel is used for grinding the width, diameter and form of the oil seal bearing.

Fig. 12. Oil Hole testing machine of Ford design.

When the grinding operations are completed, the shaft is transferred to a special Archdale combined tapping and milling machine on which a hole in the front end of the shaft is tapped and a keyway for the timing gear is cut. The milling head is built from a cam-feed drill unit with a special milling attachment. Location for this operation is taken from the end main bearings and No. 1 pin. A single quick-action clamp registering on No. 1 pin serves to hold the work securely. This machine handles both four- and six-throw crankshafts. The machine is shown in Fig. 11.

At this stage every shaft is tested for oil leaks on a machine of Ford design shown in Fig. 12. This is a precautionary measure to ensure that there are no blow holes that might cause oil leaks. As the test is carried out under pressure, it also serves a very useful purpose in clearing any swarf that may have lodged in the oil holes. The shaft is then carefully balanced both statically and dynamically Finally, all the main and throw bearings and the oil seal diameter are lapped in a Schraner hydraulic crankshaft lapping machine.

Inspection is carried out at several stages in the operation sequence and every shaft is given a full dimensional inspection when the machining is completed. A carefully designed stand gauge with all the necessary indicator dials allows the many different relationships to be determined quickly and accurately.

A remarkably high standard of finish and accuracy is maintained. For example, the main and pin bearings are all lapped to a finish that must not exceed 12 microinches R.M.S. They must also be truly circular within 0·00025 in. and the taper must not exceed 0·0005 in. in the length of the bearing. That these results are obtained with only one grinding operation on the pins and two on the main bearings is a tribute to the high efficiency of the grinding methods.

Connecting rod production

The connecting rod design is the same for both Consul and Zephyr engines. They are produced from integral forgings made in EN15 steel.

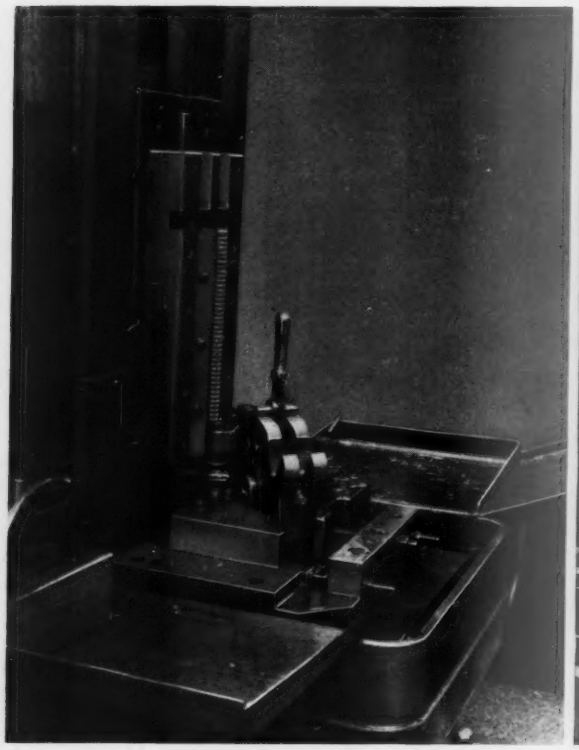


Fig. 13. Broaching two location pads on the small end of the integral connecting rod.

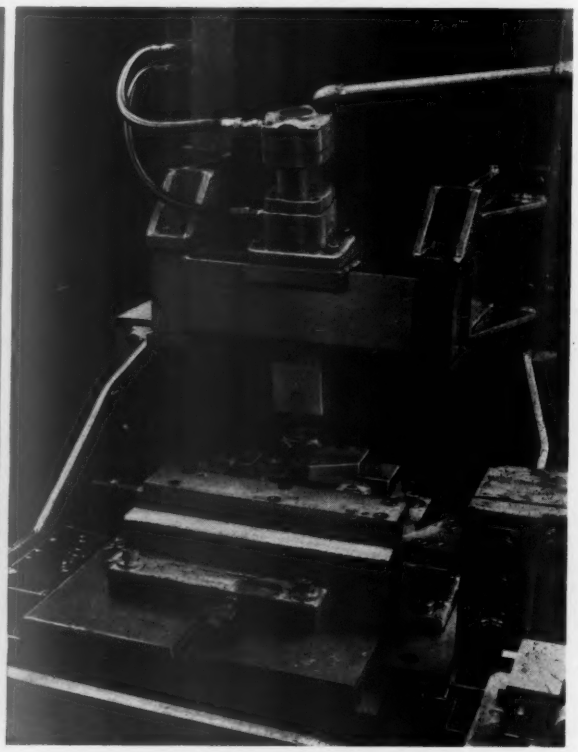


Fig. 14. The set-up for broaching the bolt boss faces and the width of the bolt bosses.

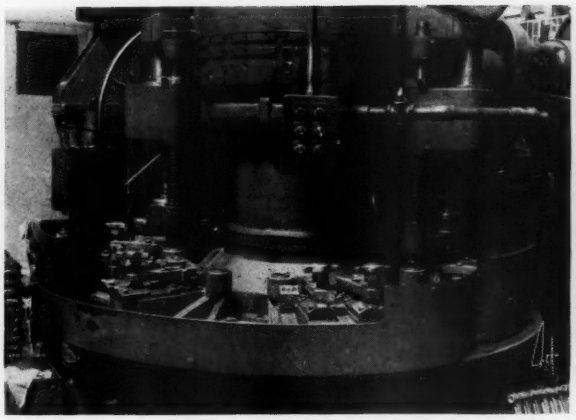


Fig. 15. Special Greenlee multi-station, multi-spindle machine for machining the small end and big end bores.

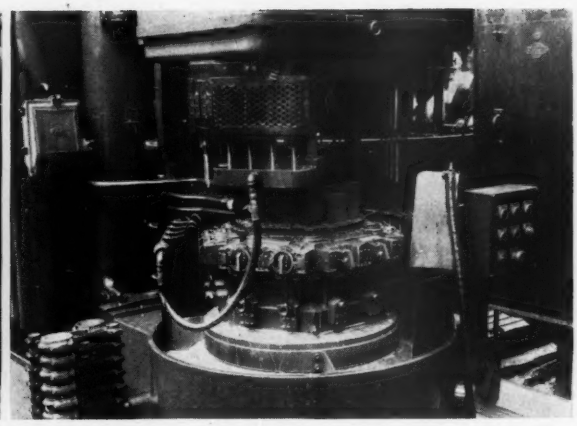


Fig. 16. Cross multi-station machine for drilling, counterboring and reaming the bolt holes in connecting rods.

As received in the machining section the forgings have been heat-treated, pickled and the ends have been coined. In the forging operation a dimple is formed in the small end to act as a location point in one of the early machining operations. At the first machining operation, carried out on a Lumsden vertical spindle, rotary table surface grinder, the large and small end faces are ground on one side and immediately afterwards on a similar machine the faces on the other side are ground to a tolerance of 0·002 in.

At this stage the small end of the rod is drilled and reamed to 0·750/0·752 in. diameter on Pollard machines. The rod is then mounted in a vertical broaching machine. Location is taken from the reamed hole in the small end from the inner form of the large end, while two locating pads on the small end are broached in relation to the reamed hole. They serve as location surfaces at subsequent operations. The set-up for this operation is shown in Fig. 13.

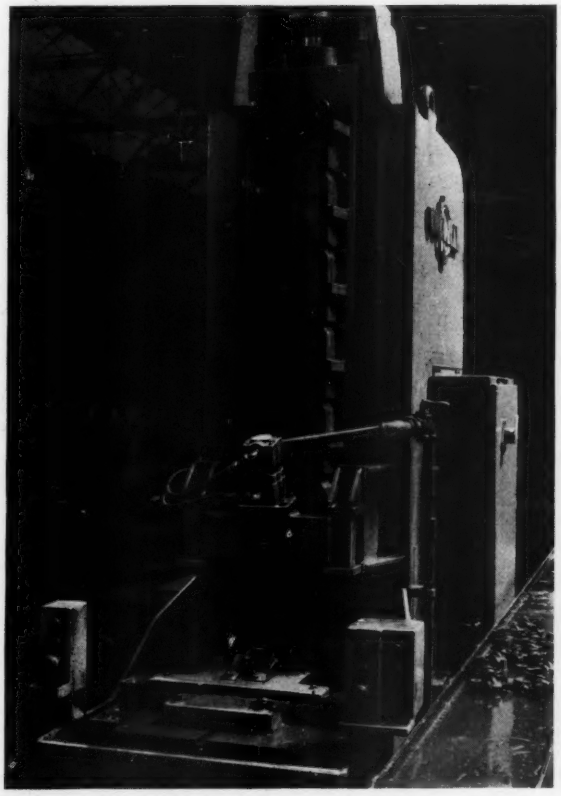


Fig. 17. The set-up for separating the cap from the rod and then shaving the joint faces.

A vertical surface broaching machine is used for the next operation on which six surfaces are broached. They are the cap bosses, the bolt head faces and the sides of the bolt bosses. A single work holding fixture is mounted on the shuttle table, see Fig. 14. This fixture is remarkably simple. The work is placed in it with location taken from the pads broached at the preceding operation and from the side of the rod. Clamping and the release of the clamp is effected automatically through a hydraulic cylinder that is interconnected with the slide actuation.

The forging is then transferred to a Pollard drilling machine in which an inserted blade boring tool is used for machining in the big end bore. The integral rod is necessarily forged with a parting allowance and this operation merely removes metal from the bore for some little distance on each side of the centre line as a preliminary to the next operation which is carried out on a special Greenlee centre column multi-spindle, multi-station boring machine which is shown in Fig. 15.

This Greenlee machine is tooled to rough, semi-finish and finish ream the hole in the small end and to rough and semi-finish bore the cap side and the rod side of the big end bore. A six-station indexing fixture is used with the following operating cycle :—

Station 1. Load.
Station 2. Rough bore rod side of big end to 1·980 in.
Station 3. Rough bore cap side of big end to 1·980 in. and rough ream small end to 0·773 in.
Station 4. Semi-finish rod side of big end to 2·022 and semi-finish ream small end to 0·792.
Station 5. Semi-finish cap side of big end to 2·0022 in. and finish ream small end to 0·815 in.

Location in the fixtures is taken from the broached pads on the small end and from the broached sides of the bolt bosses. All the spindles run at speeds that give a surface cutting speed of 60 ft. per minute and the feed in every case is at the rate of 4·43 in. per minute. At 100 per cent. efficiency this machine does 125·6 cycles per hour.

The next important operation in the sequence is the drilling and reaming of the bolt holes. This is effected on the Cross multi-spindle multi-station drilling machine shown in Fig. 16. There are six stations on this machine, one for loading and unloading and five working stations. Two rods are mounted in the work fixtures at each station. The machine has a completely automatic cycle, through the following sequence :

Station 1. Load. Location is taken from the ground faces, the small end bore and from the sides of the bolt bosses.

Station 2. Drill a counterbore 0·315/0·320 in. dia by 0·76 in. deep. The drills run at 484 r.p.m. and a cutting speed of 40 ft. per minute. A feed of 0·0056 in./rev. is employed.

Station 3. Drill 0·289/0·294 in. bolt holes. At this station the cutting speed is 40 ft. per minute and the feed 0·0051 in./rev.

Station 4. Chamfer the bolt holes on the cap side. Once again the cutting speed is 40 ft. per minute; the feed rate is 0·0067 in./rev.

Station 5. Semi-finish ream bolt holes to 0·302/0·303 in. at a cutting speed of 26·8 ft. per minute and 0·008 in./rev. feed.

Station 6. Finish ream the bolt holes to 0·3125/0·3135 in. at a cutting speed of 27·6 ft/min. and 0·008 in./rev. feed.

The total time per cycle is 46 seconds.

From the Cross machine the rod is transferred to a Pollard drilling machine on which the bolt head faces are finished, and thence to a Colonial broaching machine, see Fig. 17, on which the cap is split from the rod. A special broach is used on this machine. It first saws a slot to separate the cap from the rod, then the final section is arranged for shaving the cap face and the rod face. Before the splitting operation the rod and the cap are marked to ensure that assembly is carried out correctly at a later stage.

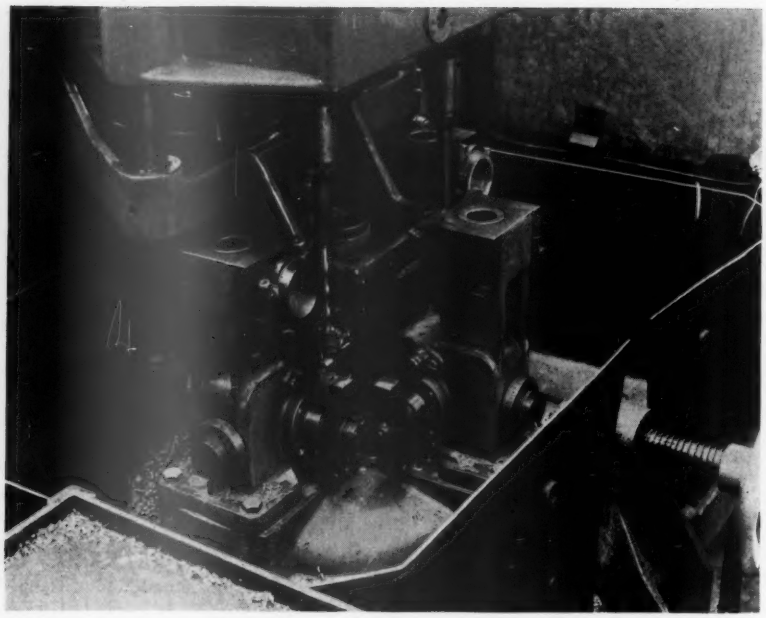


Fig. 18. Drilling, counterboring and tapping the pinch hole in the small end of Ford Zephyr and Consul connecting rods.

Simple milling, reaming and chamfering operations are then carried out before the cap is assembled to the rod. After assembly the big end bore is chamfered on each side and the rod is then transferred to a Pollard multi-station, multi-spindle drilling and tapping machine in which the pinch pin hole in the small end is drilled, counterbored and tapped. The set-up at this machine is shown at Fig. 18.

Accuracy of weight to close tolerances is specified and at this stage the big end is checked for weight and any necessary correction is made. The faces of the rod are then finish ground on a two-

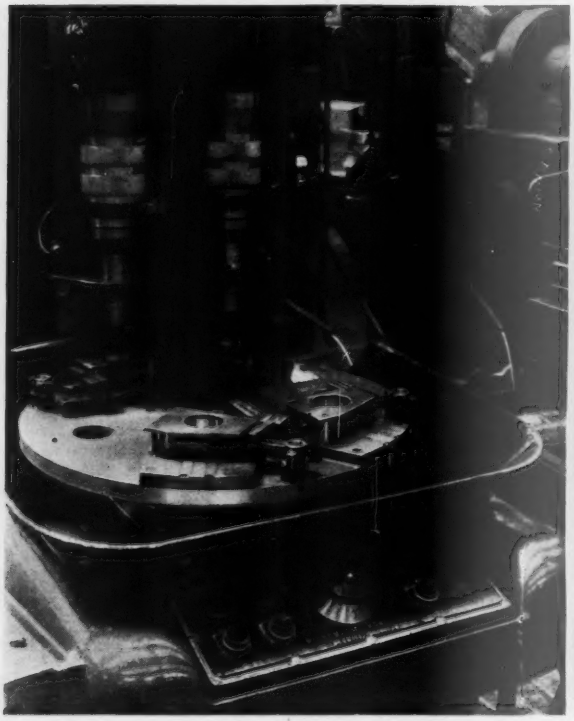


Fig. 19. Set-up for honing the large end to size on a Micromatic machine with gauge ring sizing equipment.

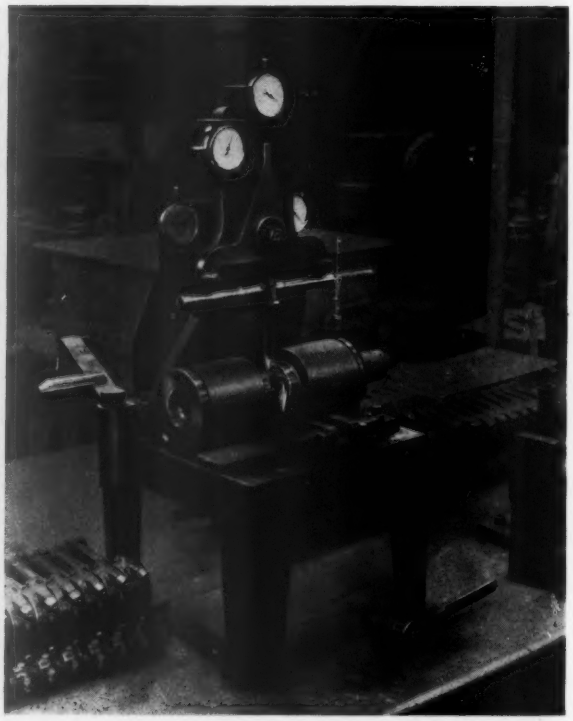


Fig. 20. Stand gauge for checking the run-out of large end side faces and the alignment of the bores.

head Blanchard vertical spindle automatic rotary surface grinder. A single rotary table passes under both heads. The work-holding fixtures are arranged alternatively for taking one side and then the other. Both sides of the small end are spotfaced and chamfered, following which the small end is checked for weight. At this stage the large end is fine bored on a Heald fine-boring machine to leave 0·001/0·0015 in. to be removed at a honing operation. A slot is then milled through the pinch pin boss and the bolt head face is machined at the same setting on a Cincinnati horizontal milling machine.

The machining on the connecting rod assembly is completed on the Micromatic two-spindle honing machine shown in Fig. 19. This is a gauge ring microsize machine with a four station indexing fixture on which two rods are finish honed simultaneously. On this machine the tool functions as an expanding plug gauge. A thermo setting plastic shell is moulded about three sides of the abrasive stone. This forms the stone-holder used in Micromold type tools. The plastic extends beyond the abrasive to form gauging tabs at each end of the stick.

As the tool rotates and reciprocates through the bore, the cutting faces of the sticks wear down. Since the abrasive and the plastic both contact the surface of the work, they wear at the same rate. Furthermore, the diameter of the stones and the plastic tabs, when in contact with the bore, is always equal to the size of the bore. A gauge ring is mounted above the part in such a manner that the tool strokes through it. This ring has an inside diameter equal to the low limit of the specified bore size. It is free to float and align itself with the tool, but is prevented from rotating by a leaf spring.

As the tool expands and the bore increases in diameter, the tabs contact the ring. When the diameter of the tool equals that of the ring, the friction between the tabs and the ring is sufficient to flex the leaf spring and cause contact to be made with a stop pin. This contact grounds a low potential circuit that initiates the "to size" signal. The hone then collapses and the head retracts to bring the hone clear of the work. Each spindle works independently as regards sizing. The surface roughness after honing must not exceed 12 microinches R.M.S., and the tolerance on bore diameter is 0·0005 in. Finally, and before leaving the detail machining section every rod is given a complete inspection. One of the gauges to simplify inspection and to ensure that the high specified standard is maintained is shown in Fig. 20.

ROAD TRANSPORT VEHICLES

Opinions on Probable Developments in the Foreseeable Future

DURING the Joint Engineering Conference organized by the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers, a paper entitled "British Mechanical Road Transport Vehicles, 1851 to 1951" was presented by John Shearman, M.I.Mech.E. and B. B. Winter, M.I.Mech.E.

The first part of the paper was largely historical, covering briefly the period from 1851 to 1925. The second part, covering the period 1925 to 1951, dealt in greater detail with the growth of the British motor industry and outlined its significant contributions to world transport. Finally a third section of the paper dealt with future possibilities and the following extracts are from this section.

In this section the author has not attempted to "crystal gaze" but rather to express his own opinions in greatly compressed form as to what we are likely to see in the way of developments in the "foreseeable" future.

The fact must, of course, be faced that many national and international influences may affect the course of events as the engineer would desire to shape them.

Therefore the views expressed are based on the premise of "peace in our time," and normal progress in the material, material supply, and fuel fields.

While the industry steps out into the future in good fettle and full of vitality, the end of the sellers' market will have to be faced before long, and "Mother Necessity" will with certainty have to accelerate "progressive invention" if continued success is to be achieved.

The Scientific Approach. To this essential end, the industry must develop its technical and scientific approach to the utmost if the competition of other countries is to be met and worsted, and in this connexion the training of technical personnel is of paramount importance.

Cost and the Specification. A problem which will have to be considered is the point at which it is going to be found impossible still further to complicate the design of the vehicle because of the effect on economics and therefore the selling price, which is all-important in the markets of the world.

Since the very early days of the motor vehicle the designer, in improving the product, has steadily complicated the design in almost every direction, but the production engineer has collaborated to the full and as the intrinsic cost of the design has gone up the actual cost of production has been pulled down owing to increased quantities and improved manufacturing technique.

Now it would seem obvious that there is a limit to the continuance of the downward curve in production costs, and this is likely to be made more difficult by the rising cost of both labour and materials. Management will, in the near future, have to face the grave question of whether in fact there may not have to be some reversion to simplification in order to meet the situation.

Passenger Cars

In this field as in others the author does not anticipate a series of revolutionary changes, but rather looks forward to a considerable period of refinement and perfection to basic units and components.

Engines. In the field of power units, particularly if anticipated fuel developments involving an octane rise up to, say, 85–90 materialize, it is thought that pronounced steps will be taken to achieve good performance with lighter power units, but above all at economy figures far in advance of anything achieved in today's production cars.

In the achievement of these results it is felt that the short-stroke engine with light reciprocating parts and improved mechanical efficiency will predominate. Although the poppet valve has so far more than held its position, it would seem that we may well see the introduction of some other type of valve in spite of past disappointments.

Much work also remains to be done within the confines of the combustion chamber.

It is probable that many developments of materials for such parts as crankshafts and blocks may be seen—the latter possibly involving the use of light alloys.

The Gas Turbine. Because of the signal success of this type of power unit in aircraft it does not necessarily follow that it will be suitable for road transport.

While we shall unquestionably see

the results of work which is either being done at the moment or which will be done in the next few years on the gas turbine, the author holds the view that there are many fundamental reasons why this type of prime mover is, in its present form, unsuitable for the road vehicle, and that the piston engine has far from reached the limits of possible development.

If the gas turbine does come within the working lifetime of any who are here today it is thought most likely to be introduced in heavy vehicle chassis, either for goods or passenger transport over long distances and at speed, and will probably find most favour in countries where fuel supplies are plentiful.

Transmission. There is likely to be intense activity under this heading, but it is not considered that the typical American solution is likely to suit our economics of tooling or production, or our operational economy demands.

On medium or large cars, the simpler form of hydraulic torque converter is likely to be adopted by many as an effective means of eliminating the clutch pedal and providing a limited range of conversion. It is also deemed desirable that a high cruising "top" should be available with an easily selectable ratio for acceleration and hill climbing.

In the case of the smaller cars, technical and economic difficulties are likely to kill smaller but similar transmissions, and the present fundamental form of gear change may well be used for some time to come, though there may be a move towards a high cruising gear and alternative traffic ratio, these being selectable by easy means.

Suspension. Although there is much detailed development work to be done, the most probable advance in the near future is the introduction of some form of automatic or manual control to adjust the suspension characteristics to suit variations in the load carried.

Independent rear suspension is a development which is certain to be seen but is not likely to appear on the volume-produced vehicle until on the one hand it has been conclusively proved that the benefits to be derived are clearcut, and that the economics have been put right.

Styling. Remarks under this heading are bound to reflect the wishes of the author. It is believed (and hoped) that the trend towards copying the United States will be largely abandoned and that British styling engineers will develop their own more practical and more dignified designs.

The principle of retaining some form of "face" or grille to identify each particular make is the trend which the author hopes to see.

Probably economics as well as other considerations will prompt the stylists towards designs which put the maximum amount of metal employed to work, i.e. to eliminate useless masses of sheet metal and decorative "embroideries."

Performance. In virtually every class an improvement should be effected in power:weight ratio—perhaps the most prominent single feature in providing an attractive machine.

Engine developments, coupled with suitable transmissions making possible a high cruising gear, should enable marked economy of operation to be achieved.

This same set of conditions should allow of higher cruising speeds so necessary in many territories of the world.

Commercial Vehicles

The remarks recorded at the beginning of this section apply very largely to commercial vehicles, but it is again emphasized how essential is a highly developed technical approach to the developments of the future.

Performance. To meet many overseas requirements where roads are good and distances great, it will be necessary to put up speeds. This in turn will demand suspension and braking improvements.

Engines. In the field of "medium" types, some form of direct injection may well contribute to the progress of economy.

Again in the medium field, it is considered that the cost differential as between compression-ignition and petrol will be narrowed, thus resulting in an expansion of compression-ignition engined models—a feature which is likely to be well received in many world territories. To meet performance improvements, power and efficiency must rise.

The comments on gas turbines under the section on passenger cars are appropriate to commercial vehicles.

Transmissions. In this field there is likely to be great activity.

It is considered that the synchromesh box in the goods vehicle is likely to increase in popularity, together with greatly improved and lighter controls.

In the case of public-service vehicles and other passenger types, easy gear changing is certain to be demanded, and although much development remains to be done it is considered that the torque converter with a subsidiary transmission and a means of locking in the "1:1 ratio" is an obvious development for the future.

Steering. In the case of many of the heavy types, a wide extension in the use of power-assisted steering is likely.

Tyres. There is every indication that the trend towards larger tyre sections and lower pressures will persist, although this may be hampered in certain types of vehicle by legislation. There is little doubt also that continued research by the manufacturers will keep pace with any higher speeds or increased loading requirements which may become general in the future.

Cabs and Driver Study. Improved comfort and control will be sought, resulting in a rise of driving efficiency. This development is likely to include wider cabs, better visibility, and better seat design and adjustment.

Heating, ventilation, and insulation must also improve.

Goods-carrying Bodies. An extension in the use of steel and light alloy is likely to take place, with the consequent reduction in the number of timber bodies.

Motor Cycles

The trend for the future in the motor-cycle world would seem to be fairly clear. The efforts of designers will almost certainly be mainly concentrated on increased refinement for touring types and reduced weight for sporting machines, alongside normal development work to produce more power, better handling, and still greater reliability for both types.

Perhaps the biggest question mark for the future is the multi-cylinder engine. The parallel twin has obviously already established itself as a firm favourite alongside the "single" but the merit of four or more cylinders, especially for racing, is still controversial.

Streamlining, starting with the total enclosure of certain short distance record breakers, has now invaded the road racing sphere in embryonic form. It is always possible that this may develop into a more definite trend although it does introduce stability problems if carried to its logical conclusion. On the other hand, if a minor degree of streamlining became acceptable for road use, its chief merit might be to contribute materially towards the rider's protection from the weather.

In short it is not anticipated that revolutionary changes to basic design will be seen in the near future but, rather, there will probably be a logical development of the existing general pattern, a still more scientific approach to methods of construction, and a steady improvement in materials.

NEW PLANT AND TOOLS

Recent Developments in Production Equipment

AN example of modern German machine tool practice is illustrated in Fig. 1. This is a surface grinder designed and manufactured by Diskus Werke, Frankfurt-am-Main. It has a vertical spindle carrying a segmental type grinding wheel and a power operated magnetic table that can be run out for loading. The spindle is housed in a slide with power operated adjustment for rough setting. Fine setting is obtained by adjustment of the grinding wheel spindle quill.

The machine illustrated has a grinding wheel diameter of 24 in. and a 40 in. diameter table. Other models, one with a 16 in. diameter grinding wheel and a 24 in. circular table, and another with a 36 in. diameter wheel and a 40 in. diameter table, are also being built. Although these machines have been designed primarily for grinding cast iron and steel, they can also be used for grinding aluminium, bronze, carbon and ceramic materials.

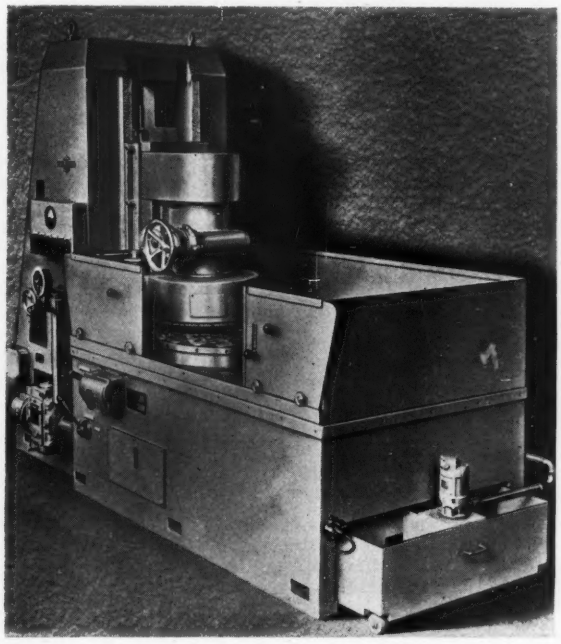


Fig. 1. Diskus surface grinder

The main upright carries the grinding wheel head, which is controlled from a push button station for rough vertical setting of the grinding wheel. Drive to the spindle is by flat belt from a 28 h.p. motor. The spindle is carried in large and totally enclosed ball and roller bearings. Fine setting of the automatic feed is obtained through a worm-operated quill. Settings for stock removal can be made to an accuracy of 0.0001 in. The circular magnetic table runs in special ways, which are fitted with automatic lubrication and are so constructed as to exclude grinding dust and other foreign matter. Drive to the circular table is taken through a variable speed unit that allows the most economical speed to be selected for every application.

At every revolution of the wheel, the grinding wheel quill down feed operates automatically. Provision is made for adjustment of the amount of down feed from 0.0004 in. to 0.002 in. per revolution. Hardened steel rollers are used for dressing the grinding wheel. They are lever-operated and can be swung into position when required, and the attachment automatically returns to the rest position when not in use. Each grinding wheel segment is bonded to a plastic base and is positioned by one bolt that screws into the plastic. This construction permits speedy mounting of the grinding wheel segments and also promotes economy, since it allows the whole of the segment to be used.

In order that full advantage may be taken of the heavy stock removal capacity of this machine, provision has been made for a copious supply of coolant, which is directed to both the periphery and the centre of the grinding wheel. This keeps the segments clean and the workpieces cool. All controls are conveniently grouped together, and push button stations control the coolant pump, vertical adjustment of the wheelhead, table drive, grinding wheel motor and table run-out traverse. A hand wheel is fitted for adjusting the speed of rotation of the circular table, and movement of a single lever causes the table to move out to the loading position. A master safety switch is also provided. As can be seen from the illustration the splash guards are mounted on rollers so that they can easily be closed and opened. Rockwell Machine Tool Co. Ltd., Welsh Harp, Edgware Road, London, N.W.2, are the agents for these machines.

Correction broaches

B.S.A. Tools Ltd., Mackadown Lane, Marston Green, Birmingham, are now producing a special type of broach for correcting bores and splines that may show distortion after case-hardening. It is illustrated in Fig. 2. This development is the result of a long period of research and experimental work. Certain components will always show some degree of distortion, no matter how carefully the case-hardening treatment is carried out, and there has long been a need for some speedy and accurate method of correction. The B.S.A. correction broach is an important contribution to greater productivity.

In the development of this broach two factors were of fundamental importance. The tool would have to be produced at low cost and a Rockwell hardness of C65-66 must be maintained to ensure a reasonable tool life. Finally, a push-type broach, suitable for use on a vertical press was made. In consideration of the very high stress values that must be encountered, the broach was kept as short as possible. The desired hardness was obtained and to get a glass-hard surface a liquid nitriding treatment was given. This extremely hard surface gives a long tool life, since the resistance to wear of a nitrided high speed steel is of a very high order.

The first broach was designed to correct the splined bores of clutch hubs and dog clutches, by burnishing both the top diameter and the side faces of the splines. Rectification of distortion was effected by pushing back the protrusion to the original level without removing any metal. This compressive action has no detrimental effect on the material and there is no risk that cracks will be started. In fact the compression tends to increase

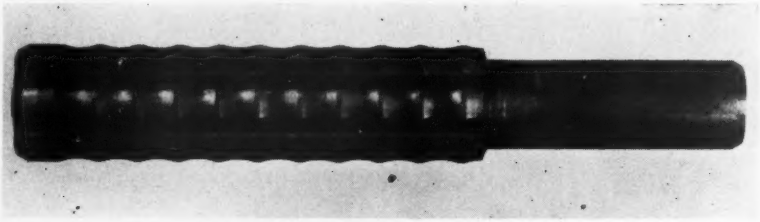


Fig. 2. B.S.A. Tools Ltd., correction broach

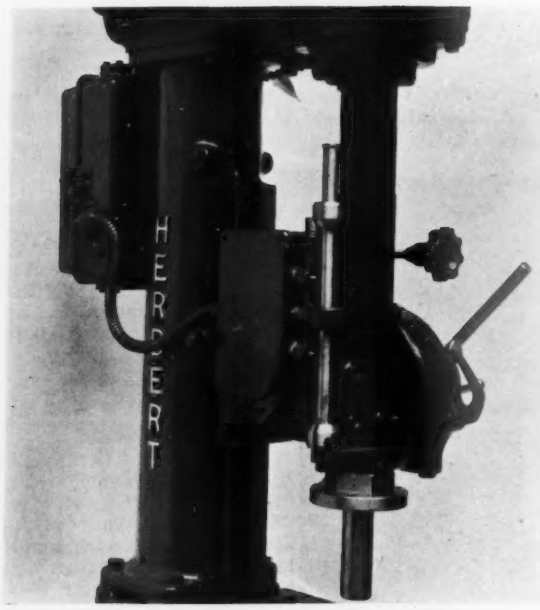


Fig. 3. Automatic reversing attachment for Herbert drilling machines

the surface hardness. This type of broach is suitable for use on components after all carbon and carbon/nitrogen case-hardening treatments. It will correct distortions up to 0.005 in. It is recommended that "Trefolex" be used as the lubricant for the broaching operation.

Excellent results have been obtained in practice. One broach has been used to correct a batch of 2,800 clutch hubs that were tight on the sliding shaft. Furthermore, this broach is still in use.

Automatic reversing attachment

An improved type of automatic reversing attachment has been developed by Alfred Herbert Ltd., Coventry, for fitting to Herbert types C and V drilling machines and to geared spindles on type V junior machines. The attachment, which is shown in Fig. 3, can be used for right-hand or left-hand threads and does not interfere with normal drilling. It can be supplied for use on any spindle having either hand or automatic feed without there being necessity to increase the distance between the columns.

The control gear consists of reversing contactors in a metal case mounted at the rear of the top column and operated by two limit switches at the front of the machine. The limit switches are depressed by adjustable collars which can be set to operate at different positions of the spindle stroke. This equipment is very robust and will stand up to hard work and give trouble-free operation over long periods.

When the attachment is fitted to type C machines the standard motor is replaced by a special reversing motor and the machine will tap up to six holes per minute. Standard type C machines which are supplied for heavy duty production work are fitted with a half-speed or higher rated motor. When the automatic reversing attachment is fitted to such machines the same motor is retained. It is not possible to fit a special reversing duty type motor. Standard motors are also retained on type V and type V junior machines. With these machines the maximum number of holes that can be tapped is three per minute.

Diecasting machine

A diecasting machine for zinc, tin and lead, recently developed by Die Casting Machine Tools Ltd., River Works, 152, Green Lanes, London, N.13, is illustrated in Fig. 4. It is designated IMP/96 and has been developed from the M55A/HF machine. The new machine incorporates a new pilot-operated "impact" injection unit, together with a power-operated die locking and opening unit manipulated through finger tip controls.

The "impact" injection unit comprises a specially designed cylinder with a pilot operated slide valve integrally built into the cylinder head. This unit is interlocked by means of a small valve at the side of the machine in such a manner that it cannot be operated until the dies are closed and locked. The chief reason for employing such a unit is to permit the use of the same metal pressures (80/100 p.s.i.) as hitherto. This increases the capacity of the shot to 12 oz. in zinc.

The power operated die unit, which carries 6 in. × 9 in. × 1½ in. die blocks for an effective projected area of castings up to 12 square inches, has a 4 in. opening. Locking is effected through four toggles of 12 tons working through two hardened and ground heavy duty tie bars of special steel. The unit is powdered by an air cylinder of ample power for ejecting castings that offer stubborn resistance to ejection. At the same time it is smooth in movement and economical in air consumption. A complete cycle takes only 0.55 cubic feet of air at 80/100 p.s.i.

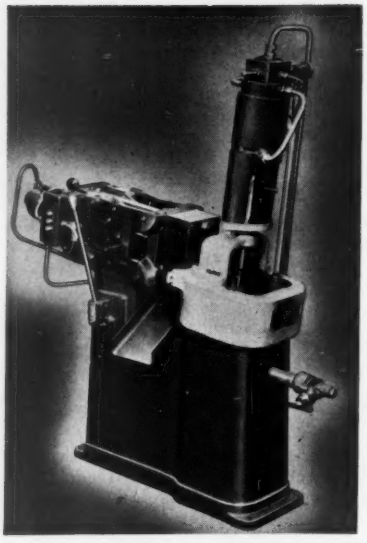


Fig. 4. IMP/96 diecasting machine

Fig. 5. "Marlco" square push broaches

Square push broaches

W. H. Marley and Co. Ltd., New Southgate Works, 105, High Road, London, N.11., are are now producing a standard range of square broaches, see Fig. 5, for the range ¼ in. to ¾ in. in steps of $\frac{1}{16}$ in. They are made to high precision standards from 18 per cent. T. high speed steel. Each of the broaches has a pilot at the small end and it is necessary to drill and ream a corresponding hole in the workpiece. This hole must be square to the face of the workpiece. The pilot diameter is in each case slightly larger than the nominal size of the cutter. There is therefore, a witness of the initial hole on each side of the broached square. The sizes of both the square and the pilot diameter are etched on each broach. The standard broaches are designed to complete the square in a

single pass, but since for some applications the pressure required for a $\frac{3}{4}$ in. broach will be greater than that which can normally be obtained on a mandrel press, there is also a $\frac{3}{4}$ in. two-stage broach that reduces the pressure for broaching 1 in. thick mild steel to approximately 2200 lb. In every case, the size of square broached with a standard broach will provide a sliding fit on spindles of nominal size.

Murad capstan lathe

A recent addition to the range of machine tools designed and manufactured by Murad Developments Ltd., Stocklake, Bucks., is illustrated in Fig. 6. It is a 1 in. high speed ram type turret lathe for which large orders have already been received from the U.S.A. Power is supplied by a three-phase, two-speed motor with a 1 : 4 speed ratio. The drive is taken from the motor to a countershaft by means of a single vee-belt and thence by twin belts to the spindle. In all, 24 spindle speeds are available. The pulleys, countershaft and bearings constitute an assembly that can be removed as a unit from the countershaft bracket.

The spindle is made from high tensile steel and is carried on generously proportioned pre-loaded ball bearings. It has a screwed nose for fitting chucks. Conversion units are available, at extra cost, to allow dead length type collets to be used. The bar feed is gravity operated and fully guarded. A special design of turret indexing mechanism is employed. It is positive in operation and does not depend upon springs. There is a choice of two types of cross slide. One is lever operated and allows fast operation on non-ferrous materials. The other is screw operated and allows heavy form cuts to be taken in steel. Both types embody the Murad micrometer adjustable rear tool slide. The principal dimensions are :—

Maximum capacity of collet . . 1 in. dia.
Swing over bed. . . . . $11\frac{1}{2}$ in.
Swing over cross slide. . . . . $4\frac{1}{4}$ in.
Movement of cross slide across bed. . . . . $4\frac{1}{2}$ in.
Maximum stroke of turret . . . . . $3\frac{3}{4}$ in.

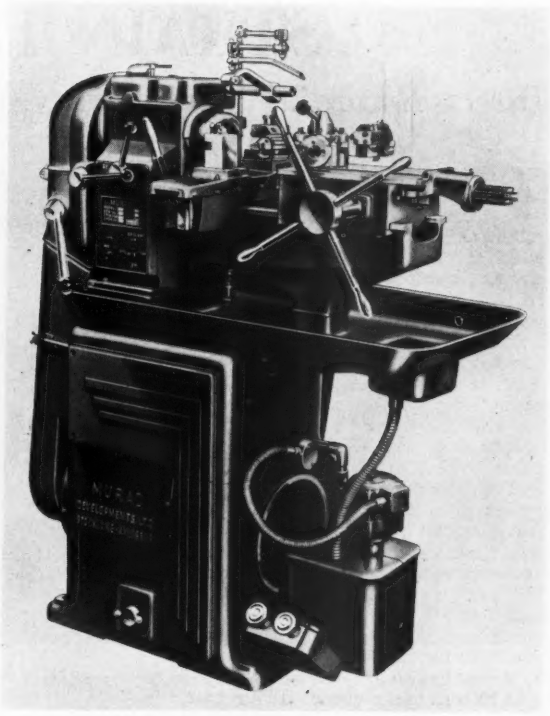


Fig. 6. Murad high speed, ram type turret lathe

Vertical hydraulic lathe

A special heavy duty, vertical hydraulic lathe designed and manufactured by Snyder Tool and Engineering Company, Detroit, is illustrated in Fig. 7. The vertical welded steel column carries a hydraulically-operated horizontal cross slide upon which are mounted two hydraulically-operated vertical tool slides. Each tool slide has tee slots and keyways for mounting tool blocks and holders. All the slides and ways are hardened and ground. The horizontal slide has 21 in. stroke and the vertical slides have 14 in. stroke. If necessary, it would be possible to use horizontal slides with a stroke up to 27 in. and vertical slides with up to 20 in. stroke.

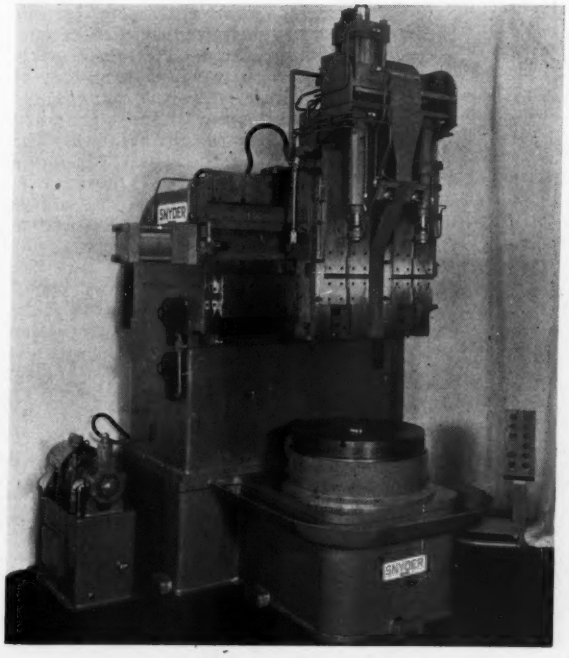


Fig. 7. Snyder vertical hydraulic lathe

A 30 in. diameter variable speed rotating table is mounted on the base. It has tee slots and a pilot for mounting fixtures or chucks. The table is mounted on pre-loaded Timken bearings and is driven through spiral bevel and helical gears. Power is supplied by a 15 h.p. motor. The drive is rheostat controlled and speeds from 46.5 to 185 r.p.m. can be obtained. Provision is made to allow the machine to be set for various combinations of automatic cycling. A large chip and coolant tank is housed in the welded steel base. Although this machine has been built for a specific application, it is adaptable to facing, turning or boring a large variety of work simply by a change of fixtures and tool holders. Gaston E. Marbaix Ltd., Devonshire House, Vicarage Crescent, London, S.W.11, are the agents for this machine.

BRITISH STANDARDS

*B.S.*57 : 1951. *B.A. Screws, Bolts, Nuts and Plain Washers, (price* 3*s.* 0*d.*). The publication of the revised edition of B.S.57 confirms as a regular British Standard, subject to certain modifications which more recent experience has shown to be desirable, the War Emergency Standard published in 1944.

General dimensions for all the common types of B.A. screws, bolts and nuts in sizes from O.B.A. to 16 B.A. are included, and the ranges of nominal sizes given in the tables are classified as "Preferred", "Second choice" and "Not normally stocked". Tables are also included relating to each type of screw showing the lengths in which each size is normally stocked and other lengths which may be regarded as standard, although they are not normally stocked. General requirements in respect of material, screw threads and finish are given and dimensions are specified for two types of washers.

Copies of this Standard may be obtained from the British Standards Institution, Sales Department, 24 Victoria Street, London, S.W.1.

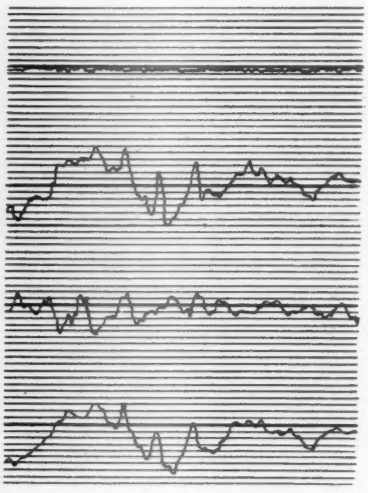
STRAIN INDICATORS

Direct Recording Instruments of Single and Four-Channel Type

THE use of direct-writing instruments for recording variable electrical quantities has, until recently, been confined to cases in which the rate of change of the quantity to be recorded was comparatively small. If frequency components exceeding a few cycles per second are encountered, the inertia of a pen recording element is inevitably too great to permit accurate reproduction of the phenomena. It has therefore been necessary to have recourse to photographic recording with Duddel or cathode ray oscillographs.

The disadvantage of photographic recording is that it is at the best a fairly lengthy process. Indeed, it may well waste a great deal of time, for most research and testing departments in industry rely upon a separate photographic department to do this work for them. The photographers are very rarely sitting around waiting for work to do, and so the recording job has to take its turn in the queue. In any case, a direct recording instrument will obviously have the advantage that it cuts out the cost of the photographic process, and the time consumed in setting up the apparatus and processing the film. In addition, the trace of a pen recorder is immediately visible, and it is not necessary therefore to wait and see if the transient phenomena required have or have not been recorded.

Kelvin Hughes (Industrials) Ltd., of 2, Caxton Street, London, S.W.1, have developed a moving coil element so efficient that it can be driven by a simple valve amplifier yet having sufficient restoring torque to enable it to deflect a stylus across its paper record in as little as 2½ milliseconds. This enables high speed phenomena to be presented for immediate inspection in a dry and permanent form. Moreover, the stiffness of the suspension renders the instrument insensitive to external vibration so that it can be used in motor vehicles under very rough road conditions.

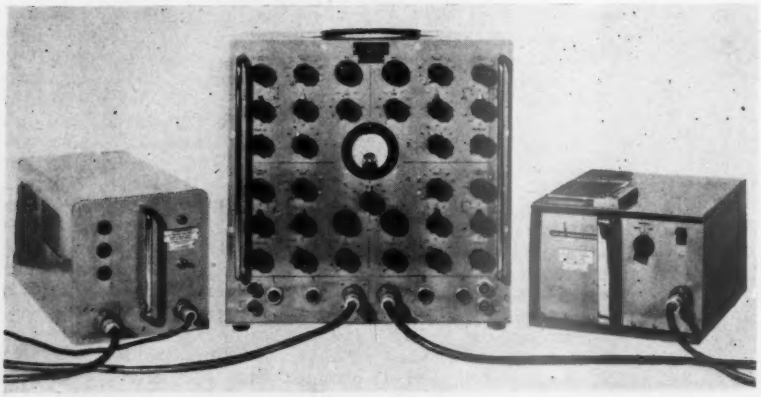


Typical four-channel trace

The range of instruments offered includes single-channel and four-channel equipment which employ Teledeltos dry electrolytic recording paper. The electric current flowing through the paper from the point of the stylus gives an instantaneous, and permanent, recording, consisting of a fine black trace on a light grey ground. A seven-pen magnet unit uses ink and plain paper for the record, and a little attention is required for keeping the pens and feed tubes clean. The electric recorders, of course, require no such attention. The electrical characteristics of the instrument depend to a large extent on the use to which they are being put, and a large variety of coil units ranging from 4 ohms to 5,000 ohms (centre tapped) resistance can be fitted, according to the source of deflecting signal and the desired frequency range. A typical coil unit for Marks I to IV recorders is 5,000 ohms (centre tapped), designed to be driven from a circuit of not more than 1,000 ohms output impedance and having a sensitivity of 0·11 mm. per volt. The response in this case is uniform within 6 per cent from 0 to 90 cycles per second. In the Mark V recorder a standard coil unit of 5,000 ohms is intended for operation from a 1,000 ohms circuit and gives a sensitivity of 0·2 mm. per volt and a uniform response from 0 to 60 cycles per second. Owing to the great variety of possibly applications of the instrument, an amplifier (type 2) is available to operate with four-pen recorders to cover normal requirements. Two types of pre-amplifiers can also be supplied when necessary.

Three units are supplied for strain recording, and the equipment includes an oscillator and power supply unit, bridge amplifier unit, and the recorder unit. It will operate with practically any variable impedance pick-up unit whether of the resistance, impedance or capacity type. The response is uniform from zero to 80 cycles per second and sensitivity is sufficient to give full deflections for a strain of 30 micro-inches per inch, using 2,000-ohm resistance gauges. Attenuators and calibrators are built in.

Multi-channel equipment has obvious uses in structural research. For example, simultaneous loads in suspension and steering mechanism components can be correlated. There are innumerable other applications for this instrument such as correlation of current, voltage, electrode force and movement in flash welding, recording of surface finish, transient response of servo mechanisms, and recording results of vehicle braking tests. The range of frequencies over which the response is uniform will cover most requirements. The only disadvantage which this apparatus may be said to have is that if an enlargement of the record for detailed study of the trace is required, it has to be done photographically, but in many cases the recorded trace is large enough, as can be seen from the full-scale reproduction on this page. (1957)



Oscillator and power supply, bridge and amplifier and recorder units

Castrol Lubrication Charts

THE latest list of lubrication charts published by the makers of Castrol, covers over 900 models, from the Austin Seven of 1928 to the latest car. Over a quarter of a million charts are in stock, and an appropriate copy will be sent to any applicant who writes to C. C. Wakefield & Co. Ltd., 46 Grosvenor Street, London, W.1, stating the make, model and year of his car.

MECHANICAL HANDLING

A Vauxhall Scheme for Dealing with Wheels and Tyres

AN interesting storage and handling system for commercial vehicle wheels and tyres has recently been completed in the new 19½-acre factory building of Vauxhall Motors Ltd., Luton. This factory now houses most of the production and assembly operations for Bedford trucks, and the new wheel and tyre store lies at the end of the building, close to the point where the vehicles are driven off the main assembly line.

Thirteen different types of tyres and eight different types of wheels are stocked in a storage area alongside the new handling installation. They are delivered to the Luton factory by road transport. A maximum stock of tyres sufficient for 3½ days' production is normally held. For wheels, the maximum stock covers 9½ days' production. At peak production approximately 1,000 complete wheel assemblies are required daily.

For purposes of description, the new mechanical handling system may be considered in relation to the following operations:—

(1) Receiving, unloading and storing wheels and tyres.
(2) Issuing wheels and tyres to the wheel and tyre assembly station, according to the production schedule.
(3) Assembling tyres to wheels and inflating them to the correct pressure.
(4) Delivering complete sets of tyred wheels to the commercial vehicle assembly line.

The tyres are unloaded from the lorries by hand and are then packed in specially designed post pallets. Each pallet holds 14 normal size tyres, that is, enough for two vehicles, allowing seven tyres per vehicle. Fork lift trucks are used for transferring the loaded pallets to the storage area, where they are stacked according to size and make of tyre.

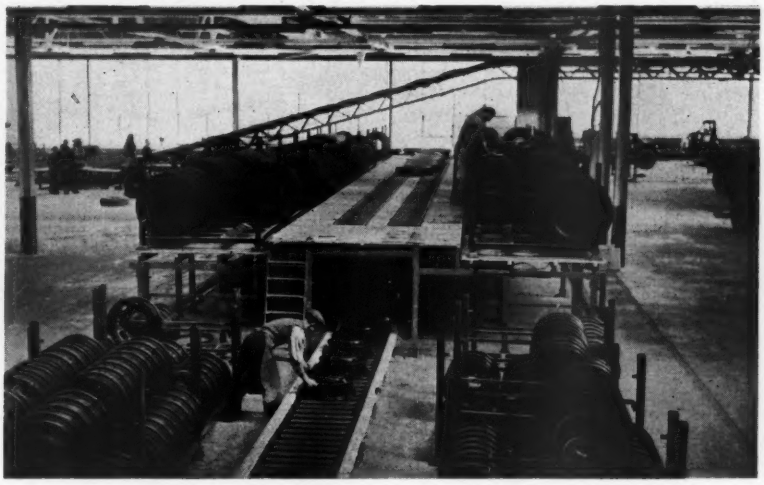


Fig. 1. Wheel and tyre conveyors from the storage area to the assembly conveyor.

Wheels, of the pressed steel ventilated-disc type, with split ring, are received with the ring ready assembled. They are unloaded from the lorries and placed in pallets by a fork-lift truck. One fork of the truck is used as a "pole" or "jib," and seven wheels can be handled at a lift. The pallets are then carried to the storage area by fork-lift truck. Each pallet holds 35 wheels, sufficient for five vehicles. Pallets for both wheels and tyres are of similar overall dimensions.

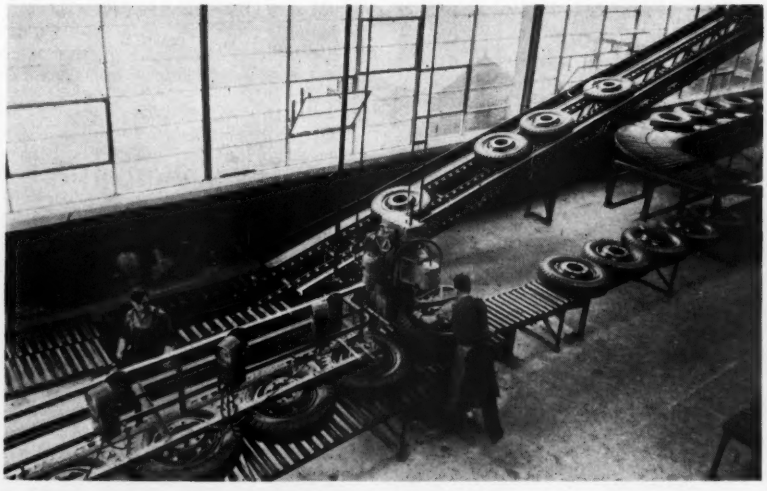


Fig. 2. Part of the wheel and tyre assembly conveyor. The conveyor for complete assemblies is in the background.

Issue of wheels and tyres to assembly point

Approximately 11,500 sq. ft. of floor space are set aside for stacking pallets in the storage area. Unit loads are carried by fork-lift truck from these stores to two power-driven conveyors, one above the other as shown in Fig. 1. One conveyor handles wheels, the other tyres. An elevated platform, 64 ft. long, 20 ft. wide and 4 ft. 9 in. high, is built around these conveyors. The tyre conveyor runs along and through the centre of the platform and at the same height above the ground. Tyres are hand-loaded on to this conveyor from pallets placed on the platform. The wheel conveyor runs directly below the tyre conveyor, at ground level.

The tyre conveyor is a double unit comprising two lengths running side by side over a distance of 64 ft. A cat-walk, 12 in. wide, separates the two lengths. Each length is constructed from two Renold chains linked by freely-mounted rollers, similar to those used in ordinary gravity roller conveyors. As the rollers rotate freely there is no need to stop the conveyor if a hold-up occurs when it is carrying a full load.

Flanking this double conveyor are cat-walks for the operator. Loading can be carried out from either side. The platform is large enough for a fork-lift truck to place a fully-loaded pallet on the platform without first having to remove an empty pallet to make room. A short length of gravity roller conveyor, with a fall of approximately 4½ per cent, carries tyres from the discharging end of the power-driven conveyor to the assembly point.

The wheel conveyor is similar in construction to the tyre conveyor, but is single track and is 28 ft. longer. This extra length constitutes the loading section. As with the tyre conveyor, idler rollers allow the wheel conveyor to be fully charged without causing necessity to stop the conveyor. Ten sets of wheels, that is 70 in all, can be accommodated at one time. Wheels and tyres are both laid flat on their respective conveyors.

At the discharging end of the wheel conveyor, each wheel is brought up to a convenient working height by means of a fully-automatic air-operated lift. The weight of the wheel as it moves over pivoted rollers, actuates a series of levers, which operate the lift and then return it to the receiving position for the next wheel. As a wheel passes on to the lift, plungers which are linked to the air cylinders come into action to hold back the oncoming wheels until the lift returns to the receiving position. When the wheel reaches the working level, it is transferred to the assembly point over a gravity roller conveyor with an average fall of 3 per cent. Only one operator is required for loading both wheel and tyre conveyors.

Fig. 3. Pfauter gear hobber converted by Vauxhall engineers for fitting split rims to Bedford wheels.

Assembly of tyres to wheels

Assembly is carried out on a 50 ft. length of roller conveyor that has flanged edges (see Fig. 2). The lips of the wheel rims fit snugly under the flanges and hold the wheel firmly while the assembly operations are carried out. There are three assembly stations along this length of conveyor. The operations carried out are:—

(1) Removal of the split rim on the wheel.
(2) Placing tyre and inner tube assembly on the wheel.
(3) Replacing the split rim on the wheel-and-tyre assembly and inflating the tyres to the correct pressure.

Tyres and wheels meet at station 2. Provision is made for controlling the flow of tyres by means of a special arrangement incorporated in the tyre conveyor. It consists of a sliding portion of roller conveyor controlled by an air-operated ram. Depression of a pedal actuates a set of three plungers, so that one is raised and two lowered. This leaves one tyre to run free but holds back the remainder, while the one tyre is carried forward within reach of the operator by the sliding part of the conveyor. The operator positions the valve of the tyre through the valve-hole in the wheel and, by pressing another pedal, retracts the slide to allow the tyre to drop over the wheel. At the same time, the plungers in the conveyor release the next tyre for assembly.

At the third station the split rim is replaced on the wheel by a machine that has been specially converted for the purpose. It was originally a Pfauter gear hobber, but has been re-designed by Vauxhall engineers to perform the rim-clinching operation without the need for using a hammer and tyre lever. This machine is illustrated in Fig. 3. It now comprises a turntable that carries the wheel and tyre under a roller attached to the work head of the machine. The roller is brought into contact with the split rim at the point of split and as the turntable rotates the roller presses the rim home. At this station the operator also inflates the tyre to the correct pressure and then transfers the complete wheel assembly to a short curved length of gravity roller conveyor that delivers the assembly to an overhead power-driven chain type conveyor.

The overhead power-driven conveyor is 280 ft. long. It starts at ground level and rises quickly to the roof the building to carry the wheel assemblies to the Bedford commercial vehicle assembly line. It automatically deposits wheel assemblies on either side of the vehicle assembly line *via* an electrically-controlled counter-balanced gate, which delivers the wheels down a short chute (see Fig. 4). Counters, actuated by the movement of the wheels, open the gate in the proper sequence to allow the correct number of wheels to be passed to each chute.

Fig. 4. Bedford commercial vehicle assembly line, showing the chutes down which wheel-and-tyre assemblies are delivered.

Installation of Reservoil Bearings

THE Morgan Crucible Co., Ltd., of Battersea Church Road, London, S.W.11, have published a pamphlet entitled *Hints on Design* for Morganite Reservoil oil retaining sintered metal bearings. It enumerates in a very concise and useful form twenty-one do's and don'ts, every one of which represents sound engineering commonsense. It is stated that the object in offering these recommendations is to give guidance in order to obtain the maximum advantage, in both operation and cost, from using Reservoil sintered metal bearings. (1968)

CENTRELESS GRINDING

An Interesting Scrivener Development for Transfer Machining

A VERY interesting application of transfer machining has recently been developed by Arthur Scrivener Ltd., Tyburn Road, Birmingham, for automatically grinding automobile valve tappets with domed heads. The component to be ground is shown in Fig. 1. It is ground on the shank at a first operation, on the domed head at a second, and is finally finish ground on the shank. The installation comprises two controlled-cycle Scrivener machines, a special grinding machine for the domed head and some interesting equipment in the form of hoppers, sorters, conveyors and feeding mechanism to give completely automatic operation.

The installation is illustrated in Fig. 2, while Fig. 3 shows the sequence of operations. Workpieces are thrown into the hopper "A," where they are picked up and aligned by a rising-and-falling sorter. From the sorter each piece passes to an automatic push-feed attachment to be fed between the wheels of the first controlled-cycle centreless grinder " B." After the shank has

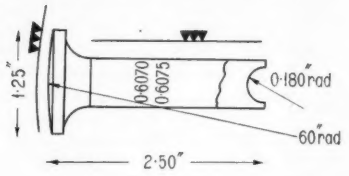


Fig. 1. Domed head valve tappet.

been ground the piece is ejected and carried by conveyor "C" to the end grinding or doming machine "D" on which the dome is ground. It is then transferred by the conveyor " E," which is a replica of " C," to a second controlled-cycle centreless grinder for the second operation on the shank. This second machine is similar to the first machine. Once the workpieces have been loaded into the hopper, all the operations and transfers are completely automatic. At practically every stage in the sequence of operations the plant incorporates interesting and novel features.

The hopper

The hopper "A" is a compartment with a vee-shaped bottom which a centre-board slotted selector rises and falls. This selector is driven by a small motor through suitable gearing. On its upward movement through the pile of components, the slot of the selector lifts most of the pieces so that they are suspended by the heads with the shanks hanging down into the slot. When the selector reaches the top of its stroke, an angle of some 35 deg. from the horizontal, the pieces slide down the track formed by the sides of the slot and drop into a tube that conveys them by gravity to the push-feed mechanism of the first centreless grinder "B." Should any piece be carried down towards the mouth of the tube in any but the correct position with the shank downwards, it is automatically knocked back into the hopper by triple toothed wheels which are interposed for this purpose, see Fig. 4.

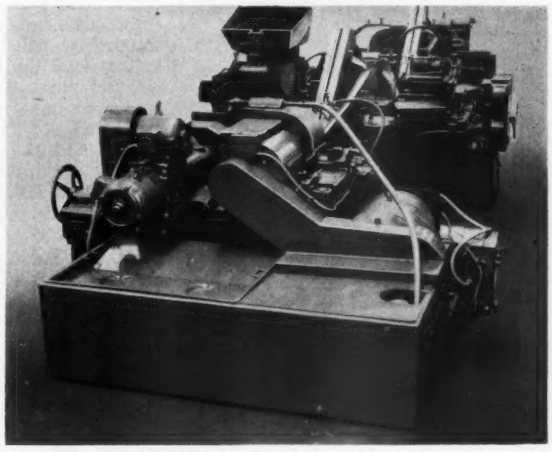


Fig. 2. Scrivener transfer grinding installation for the tappet shown in Fig. 1.

A push-feed mechanism feeds the piece between the wheels of the centreless grinding machine for plunge grinding. It is based on the standard Scrivener mechanism. When the control and grinding wheels are open, a pusher actuated by an hydraulic cylinder advances to push the piece deposited in its path on to the workplate between the wheels. These wheels then close and the piece is plunge ground on the shank. The wheels then open, and as the piece is freed a hook at the end of the pusher withdraws the ground piece from between the wheels and ejects it into a tray. From the tray the work slides into a chute that carries it to the first conveyor. At the conveyor end of this chute there is a slot sufficiently wide to allow the shank of the tappet to fall through so that it is suspended by the head. By means of this simple device the work is always transferred to the ramp of the conveyor hanging with the shank down.

The conveyor

After the first grinding operation on the shank, the pieces are carried by the conveyor shown in Fig. 5 to a vertical feed tube that feeds the special machine for grinding the domed head. The pieces are raised to the mouth of the feed tube, shanks down, along an inclined slotted ramp by a special conveyor chain running immediately below the slot. This chain has projecting pins at intervals to engage the shanks of the pendant pieces.

The first length of the feed tube into which the work is dropped from the conveyor is vertical, merging gradually into the horizontal. The weight of the column of work in the vertical length of the feed tube is sufficient to eject the leading piece on to a transfer slide against a stop. Naturally, the carrying capacity of any conveyor feeding an automatic machine must be in excess of the actual machine requirements to ensure there will be no idle strokes due to

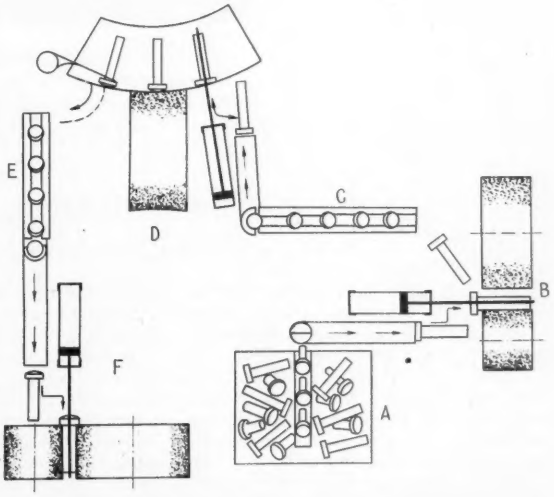


Fig. 3. Diagrammatic illustration of the operation sequence.

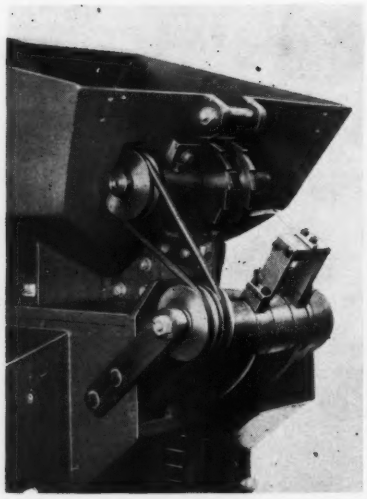


Fig. 4. The feeding hopper.

lack of workpieces. Because of the excess capacity of the conveyor a by-pass arrangement is interposed between the delivery end of the conveyor and the start of the feed tube. It is designed to return any excess pieces to the starting point. This by-pass consists of an inclined tray around the opening to the feed tube. Should the tube be filled with a column of work, the excess pieces merely slide over the blocked opening down the tray and into an inclined chute for return to the bottom end of the conveyor.

End grinding machine

A special-purpose end-grinding machine has been developed to generate the dome on the head of the valve tappet. For this operation the piece is supported on two idler rollers, rotated by a control wheel resting on the shank and moved in an arcuate path across the periphery of a grinding wheel that has been formed to the required radius. Wheel forming is effected by means of a form-truing attachment controlled by a former. On completion of its passage across the grinding wheel, the piece is automatically ejected.

On this machine the tappet is delivered by the conveyor to the loading platform of the transfer slide as shown in Fig. 6. To start the cycle, the pusher of the push-feed mechanism advances the piece into the throat formed by the two supporting rollers and the raised control wheel. At this point the arcuate slide starts its sweeping movement across the periphery of the formed grinding wheel, and the continuously rotating control wheel, under the influence of a cam, drops down to the shank of the tappet and rotates it during its passage across the grinding wheel.

At the end of the travel across the face of the grinding wheel, the control wheel is raised by cam action to release the work. Meanwhile the head of the tappet has, by the movement of the slide, been pushed between the fingers of a spring-loaded extractor. The mechanism of this extractor has been previously cocked and it throws the released tappet into a chute leading to the second conveyor. At the same time the arcuate slide is automatically reversed and returned to the starting position for the cycle to be repeated.

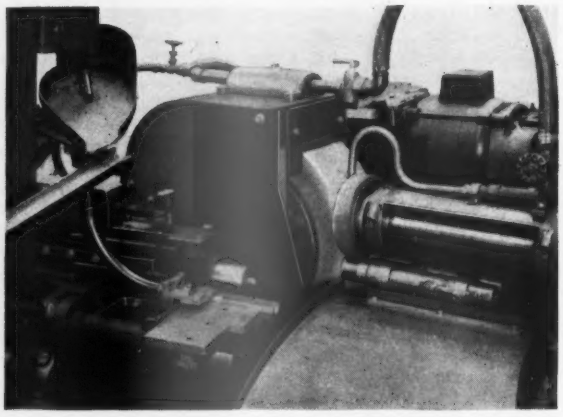


Fig. 6. The end grinding machine for producing the domed form.

Actuation of the push-feed mechanism and of the arcuate slide is effected

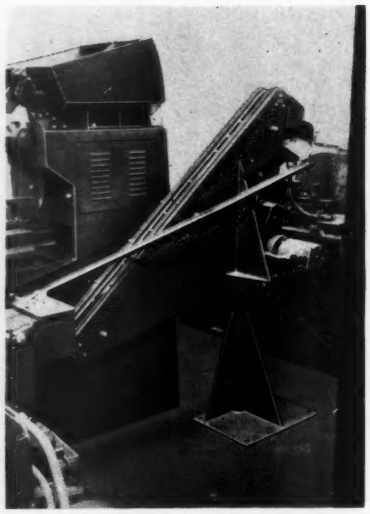


Fig. 5. The conveyor from the first centreless grinder to the end grinding machine.

hydraulically under the control of electro-hydraulic valve gear. As the profile of the grinding wheel is formed from a form-truing attachment under the control of its own independent former, the cut can be varied to give the desired "spread" to the grinding load over the periphery of the wheel. In other words, the rate of stock removal can be varied to obtain optimum results. This is important, since a high degree of finish, about 8 micro-inches, is an essential feature of this operation.

The conveyor that carries the work to the second centreless grinder is in all respects exactly the same as the first conveyor. Similarly, the machine for the final operation is a complete duplicate of the machine used for the first grinding on the shank. The stock removal involved in these operations is in the order of 0.010 in. and the net production is at the high rate of 300 pieces per hour.

MONOCHROME and VAN DER HORST

Hard-Chromium Plating Firms Combine

AN agreement has been reached between the Birmingham Small Arms Co., Ltd., on behalf of their subsidiary, Monochrome Limited, of Redditch, and the Van der Horst Company of Holland, under which each company will use either of their two proprietary processes of hard-chromium plating cylinder liners.

Messrs. Van der Horst will operate the Monochrome "Honeychrome" process in Holland, and Messrs. Monochrome, the Van der Horst "Porus Krome" process in the United Kingdom.

For some time both processes have been operating in the engineering industries, and under the new arrangement the combined technical resources and research facilities of both organizations, built up over many years, will be at the service of these industries, and particularly of manufacturers and users of cylinders and liners of all types. The agreement confers upon Monochrome Ltd. the exclusive right under the Van der Horst patents to operate the "Porus Krome" process on a jobbing basis in the United Kingdom, and also confers upon the Van der Horst Company of Holland the exclusive right under the Monochrome patents to operate the "Honeychrome" process on a jobbing basis in Hilversum, Holland. (1971)

AIR CONDITIONING*

Some Factors in the Design of Equipment for Passenger Vehicles

By F. W. Duncombe+

THE air conditioning of any space invariably calls for the employment of some form of heat exchanger, and before such can be considered, it is essential to have knowledge of the basic laws of heat transfer. These laws of heat transmission have a controlling influence on the design of the various forms of heaters, coolers, etc., which are found in every day applications.

Mechanism of heat flow

The transfer of heat from one object to another or through any substance is created by temperature difference, i.e., heat passes from a hot object to a cooler object, the greater the difference in temperature between the two objects the higher is the rate of heat flow. Heat, in some amount, is present in all substances at ordinary temperatures.

It will be obvious that as the temperature of a substance is reduced, it possesses less heat, and with progressive lowering of temperature, there will be a corresponding reduction in the amount of heat possessed, the heat content becoming gradually less as the absolute zero of temperature is being approached—which is about 460 deg F below zero.

When the term "heat" is used, it is liable to give the impression that a substance is hot, but consider a case in the lower temperature field :—If a substance were at 0 deg. F. (32 deg. below freezing point) it would still possess more heat than—say, a substance which had a temperature of —50 deg. F., and if the circumstances were suitable, the substance at zero deg. F. would give up heat to the substance at —50 deg. F.

The flow of heat can take place in three different ways :

1. Radiation
2. Conduction
3. Convection

1. *Radiation:* A hot body will give off heat in the form of radiant energy which is transmitted in all directions. If some of this energy strikes another body, part may be reflected, part may pass through the separate body and the remaining energy may be absorbed and transformed into heat. For example, if two bodies, one of which is hotter than the other, are placed in a closed compartment, there is a continuous flow of heat from one body to the other until a form of equivalent temperature is reached. The heat flow due to radiation in low temperature heat interchangers is at a minimum, and is usually ignored when forced convection exchangers are under consideration.

2. *Conduction:* This is the mode of heat transfer from one part of a body to another part of the same body, or from two bodies which are in actual contact with each other. This action takes place without any appreciable displacement of the particles of which the body consists. The heat flow through the bodies or substance due to conduction varies according to the thermal conductivity of the substance. There is an enormous variation in the thermal conductivity of substances. It is extremely high in metals, and very low in insulating materials, water, air, oil, etc.

Table I gives a few values of the more important physical characteristics of well known substances and includes the thermal conductivity values of the substances.

Thermal conductivity must not be confused with surface conductance. In a heat exchanger, heat will flow across the metal wall of the tube, through the metal of the extended surface and across the thin film of the fluid, which is either adherent to or flows parallel to the surface with which it is in contact.

This surface conductance or "film rate" is one of the most important concepts in heat technology. It is defined as the quantity of heat transferred across one sq. ft. of surface in one hour, for each degree Fahrenheit of temperature difference between the surface and the fluid medium with which it is in contact. The surface conductance is assisted very much by the influence of convective flow.

3. *Convection:* Convective heat flow is the transfer of heat from one part of a fluid to another part of the same fluid by the mixing of portions of the fluid with one another. It should be noted that the fluid motion can be due to various causes—i.e., it can be created by the difference in density resulting from the temperature difference available, as in natural convective flow—industrial convection heaters and thermo-syphon cooling systems on cars, etc.

The motion can, of course, be produced by mechanical means as in forced convection; that is to say, air can be made to move by fans and is thus mixed. In the case of water, oil and other fluids, pumps are used to create flow and therefore aid the mixing. Convective flow is also influenced by the fluid velocity, viscosity and degree of turbulence present. These influences affect the thickness of the fluid film which is in contact with the surface and they help to disrupt the stagnant film which may in some cases be adherent to the surface.

Table I

Substance	K Thermal Conductivity B.T.U's/Hr. Sq.ft/deg.F/ft.	U Viscosity Absolute Lb/ft. hr.	P Density Lb/cu. ft.	Specific Heat	Temp. F.
Air	0·0137	0·041	0·0807	0·24 @	32
,,	0·016	0·048	@29·9 Hg.	29·9 Hg.	140
,,	0·0176	0·053			212
Hydrogen	0·0942	0·0208	0·00561	3·44 @	32
,,	0·12	0·026	@ 29·9 Hg.	29·9 Hg.	212
Water	0·321	4·34	62·5	1·009	32
,,	0·379	1·13	61·4	0·998	140
,,	0·397	0·686	59·8	1·005	212
Oil D.T.E.	0·0727				32
,,		220	54·8	0·469	110
,,		95	54·1	0·481	140
,,		48·6	53·5	0·493	170
Copper	223		558	0·095	32
Pure Iron	39		490	0·109	32

* A paper presented to the Institute of Road Transport Engineers Ltd.

+ Development Engineer, The Clayton Dewandre Company Ltd.

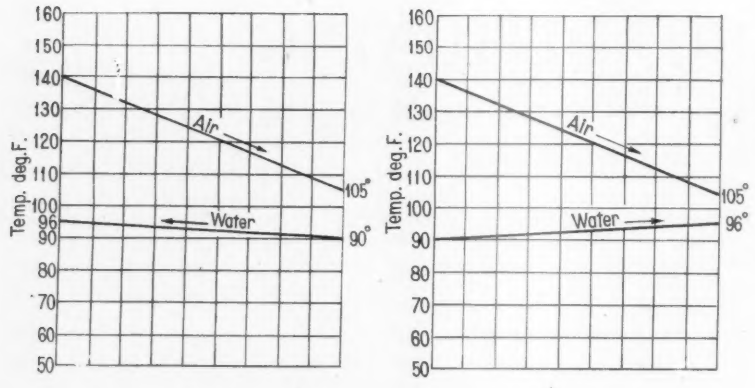


Fig. 1. Temperature difference curves
(a) Contra flowing fluids (log mean temperature difference=27 deg. F.) (b) Parallel flowing fluids (log mean temperature difference=24 deg. F.)

Convection conveys the heated or cooled fluid to and from the surface at the maximum temperature difference that is possible, and this assists in the improvement of the heat transmitted.

It must be realized that only in rare circumstances does one of the above modes of transmission work entirely upon its own. In most cases found in practice, the three methods of transmission are combined but the extent of each method is dependent upon the application.

It is also necessary to draw attention to the expression "radiator"—this term is often used in an incorrect sense. For example, "radiator" is frequently used to name the appliance which is used for cooling internal combustion engines, and it is an example of where all three modes of transmission are used. Consequently, a better term would be "heat exchanger".

It was stated in the opening remarks of this paper that the transfer of heat from one object to another or through any substance is created by temperature difference, the basis of this being that heat will always flow from the object or fluid which has the higher temperature to the fluid which has the lower temperature.

Temperature difference must be fully understood as it controls the performance of any heat exchanger. It will be realized that for a given duty, a heat exchanger which is working at the greater temperature difference will have to dissipate less heat per degree of difference available than an exchanger working under lower temperature difference conditions.

For example :

	Condition A	Condition B
Dissipation required	254,000 B.T.U's/hr.	254,000 B.T.U's/hr.
Air temperature	100 deg. F.	150 deg. F.
Maximum water temperature ..	200 deg. F.	200 deg. F.
Temperature difference.. ..	100 deg. F.	50 deg. F.
Dissipation required per degree	2540 B.T.U's	5080 B.T.U's

It will thus be seen that for the required dissipation, a heat exchanger designed for condition B would have to dissipate twice the amount of heat in the same time to give the equivalent performance required for condition A.

When making comparisons of any form of heat exchanger, the usual practice is to resolve the performances required to a common temperature difference base of 100 deg. F. The method outlined is sufficiently accurate for small applications but where more accurate figures are desired, the log mean temperature difference is generally used.

This method takes into account the fact that air on its way through a heat exchanger is continually changing in temperature, and in consequence the temperature difference between the air passing over the element and the fluid flowing through the tubes is also changing. The result of this is that the temperature difference curve forms part of a hyperbola and follows hyperbolic logarithmic laws. This can be shown by the equation :

$$\text{Log mean temperature } Tm = \frac{T_1 - T_2}{\text{Log}_e \frac{T_1}{T_2}}$$

where T_1 is the greater temperature difference and T_2 is the smaller temperature difference.

In certain cases where extremely low temperature differences are encountered, contra flow of the fluids is often adopted. Fig. 1 shows graphically the difference obtained for the log mean T.D. with parallel and contra flows.

Operating factors and conditions

Passing from the basic fundamentals, it is now necessary to study the various conditions encountered in practice, and the factors which control the conditions. It will be understood that there is available certain knowledge derived from the industrial heating and ventilation field, which can be applied to the air conditioning of passenger vehicles, and it thus becomes necessary to define the factors which affect such installations. These factors have a controlling influence on the comfort conditions desired, and can be classified thus :

1. Temperature
2. Humidity
3. Air movement
4. Air quality

The foregoing which, it is known, must affect the comfort conditions, are not easily controlled, and unfortunately there is no scientific definition or expression which can define comfort accurately, but attempts have been made and a certain amount of success achieved. For example, there is the difference of the individual to be considered, and it is generally only possible to achieve a degree of conditions to suit the average individual.

Knowledge, however, is available which does help in formulating ideas of what is required—it is known for example that the human body is continuously generating heat which is known as internal metabolism, and in order to maintain the normal body temperature, a certain amount of heat must be given off by the human body to maintain a healthy state. If this function does not take place, and a state of equilibrium is not maintained, a degree of discomfort is experienced.

1. *Temperature:* Dealing now with the items enumerated, "effective" temperature must be considered. It will be noted that the word "effective" has been added. Whilst a certain temperature can be attained, it does not necessarily mean that bodily comfort has been achieved.

Bodily comfort is very closely associated with the humidity of the atmosphere, and this entails a knowledge of the principles of wet and dry bulb temperatures. It is thought advisable at this stage to define humidity, its features, and revert later to "effective" temperatures. Wet and dry bulb temperatures are associated with humidity and to assist in an understanding of this particular subject, the following definitions are given:

2. *Humidity:* Humidity is the moisture or the water vapour mixed with the air in the atmosphere. The weight of water vapour that a given

space will hold is dependent entirely upon the temperature.

Relative Humidity: Relative Humidity is the ratio of the weight of water vapour in a given space to the weight which the same space is capable of containing when fully saturated at the same temperature. It is the ratio of the absolute humidity for the given condition to the absolute humidity at saturation. The quantity of moisture mixed with the air under different conditions of temperature and saturation is usually determined by means of some form of instrument in which dry bulb and wet bulb thermometers are incorporated.

Dew point: Dew-point is the temperature at which saturation is obtained for a given weight of water vapour. It is the point where any reduction in temperature would cause condensation of some of the water suspended. Any given amount of moisture must have a particular temperature at which saturation occurs and any further lowering of the temperature will cause condensation . . . this is the dew-point of the mixture.

The temperature of air is normally measured by an ordinary or dry bulb thermometer. The wet bulb thermometer has the bulb covered with a piece of cloth which has previously been dipped in water and wrapped around the bulb. It is usual when taking readings to swirl these thermometers, or to place them in a moving stream of air. The wet bulb thermometer will give a depressed or lower reading than that of the dry bulb thermometer and this depression is in proportion to the evaporation from the wet surface of the cloth. The depression registered is a measure of the amount of moisture in the air and gives an indication of the temperature at which air would normally saturate without any change to its heat content or enthalpy, that is to say, the total heat in the air remains constant for a given constant wet bulb temperature.

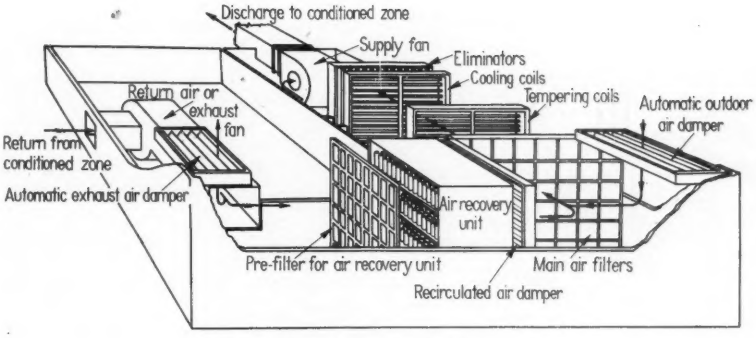


Fig. 3. Recirculating air purification unit

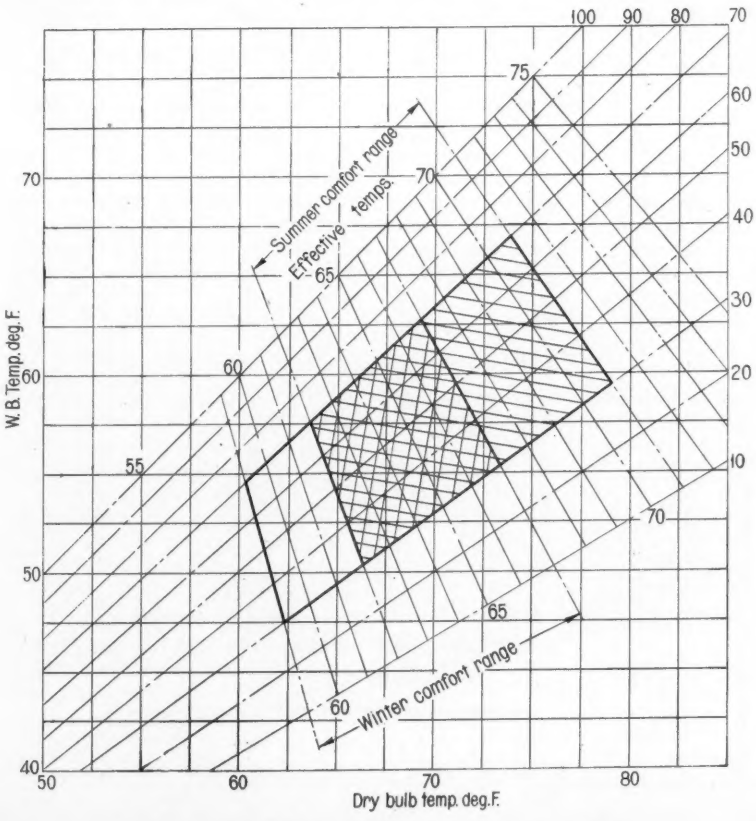


Fig. 2. Effective temperatures, summer and winter conditions

Relation of dry-bulb, wet-bulb and Dew-point temperatures: Dew-point, as already stated, is the temperature at which saturation is obtained for a given amount of water vapour. In other words, the air is at dew-point when it contains all the moisture it will hold at a given temperature and it is impossible to persuade the air to absorb more vapour without raising the temperature.

When air has been reduced to the dew-point, both wet and dry-bulb thermometers will read exactly the same, and if, for example, the air is at a temperature of 50 deg. F. and 100 per cent saturation, there will be approximately 53 grains of moisture per lb. of air; under these conditions, both the wet and dry bulb thermometers will register 50 deg. F. If heat be applied to the air, both thermometers will start to rise, but the wet bulb thermometer will rise much more slowly than the dry bulb, and the relative humidity will, in consequence, be reduced. It will be noted that the dew-point will remain constant at 50 deg. F. since any given number of grains of moisture per lb. has a fixed and definite dew-point, i.e., a temperature of saturation.

Reverting for a moment to temperature and to the remarks concerning humidity, it will be appreciated that the two are so closely interconnected that they must be treated jointly. As a result of many experiments, both here and in the U.S.A., the expression "effective temperature" has been derived. This "effective temperature" does not take into account the effects of radiation and is an expression of what could be termed the "scale of comfort."

These investigations show that if the dry bulb temperature of the air in which a person is situated is very high, it will cause discomfort due to perspiration and, if, on the other hand it is too low, a feeling of chilliness is experienced. It must also be borne in mind that the same dry bulb temperatures do not hold good the whole of the year round. In a confined space such as a room or a vehicle, the dry

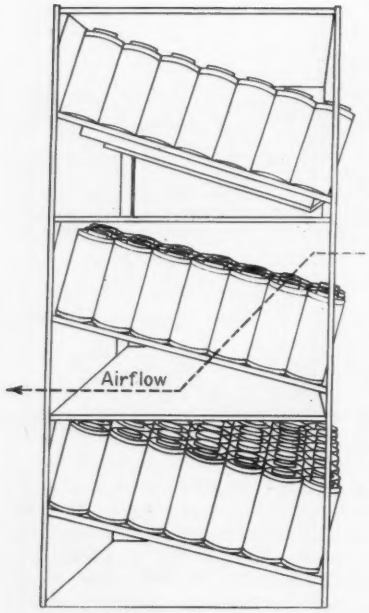


Fig. 4. Battery of carbon canisters

bulb temperature must have a relation with the conditions prevailing outside.

Consider a room maintained at 60 deg. F. during the summer months, with an outside temperature of up to 80 deg. F., a person upon entering the room would experience a feeling of chilliness; yet in the winter time, a temperature of 60 deg. F. would be considered quite reasonable. Certain authorities have found that the most suitable dry bulb temperatures for this country should be between 60 deg. F. and 70 deg. F. for winter conditions, and between 64 deg. F. and 79 deg. F. for summer conditions. These ranges depend upon the prevailing humidity —if the air be very dry, it may be the cause of dry throats, and, on the other hand, if too moist, a feeling of clamminess is experienced.

There are a number of conflicting statements regarding what the range of humidity should be, and it has been suggested that air at 30 per cent relative humidity would be too dry and 70 per cent too moist. It is recommended that for average conditions, the range should be between 40 per cent and 60 per cent.

Based upon a psychrometric chart, Fig. 2 has been compiled showing the "effective temperatures" for summer and winter conditions. The summer "comfort zone" has limits of 62 to 71 "effective temperature" while the winter conditions considerably overlap the summer range and has limits of 59 to 67 "effective temperature." For the same degree of comfort—i.e., 62 "effective temperature" there are two conditions which will give this effect, viz :

(a) 66 deg. F. dry bulb—50 deg. F. wet bulb—30 per cent relative humidity.
(b) 63 deg. F. dry bulb—57 deg. F. wet bulb—70 per cent. relative humidity.

Other combinations can be made to suit the selected "effective temperature."

3. *Air movement:* Air movement is associated with the number of air changes per hour recommended for normal satisfactory conditions. If the air movement in an enclosure is not sufficient, one is soon aware of a feeling of stuffiness; but on the other hand, should the air movement be excessive, there is a liability of creating draughts.

This question of draughts is also a point which needs certain consideration and it is extremely difficult to define accurately what is a draught. It has been stated that an air velocity of 30–40 ft. per min. is sufficient to create a draught but it must be realized that temperature must have some bearing upon this feature.

If one is in a room with an air temperature of 70 deg. F. and the air speed is about 50 ft. per minute, this may cause a feeling of a very pleasant breeze, but if the room temperature was reduced to—say—50 deg. F. and the air velocity reduced to—say—20 ft. per minute, there would, in all probability be a complaint registered concerning the amount of draught. It is suggested that for average temperatures, the air velocity should be about 40 ft./minute but if the temperature is high, the velocity can be increased to—say—80 ft./minute.

4. *Air quality:* Turning now to the question of quality—whilst this very desirable feature can be considered for industrial and domestic air condition plants, it is not so easy to apply effective and adequate air filtration to a commercial passenger vehicle. To a degree, the type of filter that can be used in a vehicle is dependent upon the power of the fans and also upon the space available. It is as well to draw attention to the fact that if a filter is installed on the air intake side of the heating air ventilating unit, it does not ensure that the air in the vehicle is necessarily filtered. Impurities will be admitted through the windows and through the doors when passengers are boarding or alighting.

Air quality brings into the picture another aspect of the situation insofar as it is possible, with suitable types of filters, to use the vitiated air over again. From the point of view of industrial applications, this factor is well worth considering as economically the saving in fuel—whether it be coal or oil—can be quite considerable. The principle can be likened to the use of heating feed water for steam raising boilers.

Generally, when recirculated air installations are being considered, it is usual to provide a supply of fresh air which is controlled, and this arrangement ensures that an adequate supply of oxygen is available. The average proportion for the recirculated and fresh air is about 2/3 recirculated to 1/3 fresh. This arrangement ensures that :

(a) the oxygen consumed is replenished, and
(b) the accumulated air contaminating impurities are diluted.

The air needed to satisfy the first requirement must be new outside air whether or not it is fresh, i.e., uncontaminated. For the second requirement, the air must be fresh regardless of whether it is outdoor air or otherwise.

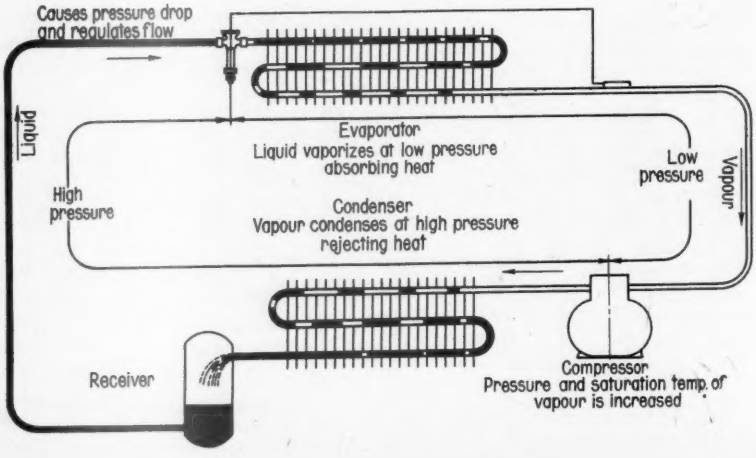


Fig. 5. Passenger vehicle air conditioning unit

The volume of air required for oxygen replenishment is negligible compared with the volume required for dilution. The latter may be approximately fifteen times that of the former. The filters which are used for absorbing the impurities in the air which has already been contaminated, are usually of the activated carbon type. In practical ventilation, it has been found that with properly designed equipment, employing carbon filters of the correct standards, the following minimum quantity of carbon per 1,000 cu. ft/minute of air to be decontaminated would be adequate.

Type of Ventilation	Lb. of Carbon per 1000 C.F.M.	Average life between reactivatings
Domestic	25	2 years or more
Commercial	35-40	1 or 1½ years
Industrial	60 or more	½ to 1 year

(Fig. 3 shows a diagrammatic view of an air recovery unit incorporated in an air circulating system. Fig. 4 illustrates a battery of carbon canisters used in such systems.)

Operating conditions

There is little really that can be said about this particular item, as conditions vary so extremely and it is obvious that within the scope of practical limitations and expense, the designer will bear in mind the ultimate destination of the vehicle when the type of installation required is being specified. Before leaving the subject, however, it would be interesting to consider some of the investigations which have been carried out concerning the average amount of heat required in any particular part of the year for a given locality.

The original investigations were made in the U.S.A., and certain investigations have also been made in the United Kingdom. These investigations show that when the average internal temperature in a heated building is 70 deg. F., no heating is required when the external temperature is 65 deg. F.—this giving rise to the thought that there is sufficient internal heat generated in the building to give a rise of 5 deg. F., this amount of heat being obtained from the body heat of the occupants and from electrical appliances such as lighting equipment, domestic appliances and the like. There is also a certain amount of heating to be obtained during various times of the year when solar radiation is fairly high, and the heat storage capacity of the building is sufficient to maintain the temperature over a very long period of the day.

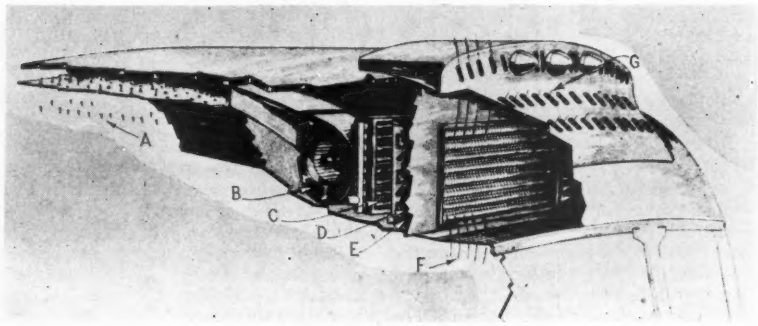


Fig. 6. Air conditioning installation in a roof
A. Conditioned air. B. Fan. C. Reheat coil. D. Evaporator. E. Drip pan. F. Return air.

Arising out of these investigations an expression—"Degree-day" was invented, and a degree-day is said to exist when the external average temperature over 24 hours is 1 deg. F. below the base temperature. If the base temperature is 60 deg. F. and the outside average temperature is 10 deg. below this figure, that day will have 10 degree-days. Therefore, the number of degree-days that are obtained on any particular day of the year is devised by subtracting the average daily temperature from the base temperature. If this investigation be made for each day of the year, the sum of the values is annual degree-days. (See *Heating and Ventilating Industry Year Book*.)

It will be obvious that the information given by a chart indicating the annual degree-days for particular parts of the country is extremely useful for industrial and domestic heating, but is not so useful when applied to the subject under discussion. Such a chart does show, however, that even in this country, vehicles stationed in different localities do not necessarily require the same air conditioning equipment. It also brings to notice the fact that for vehicles which are operating in different parts of the world, the air conditioning of the vehicle is dependent upon the operating conditions. Although concerned, in the main, with the air conditioning of vehicles, as used in our own climates, it is nevertheless interesting to study briefly the installations required for vehicles operating in very hot climates, or in climatic extremes. In such cases, a combined form of air conditioning apparatus is necessary with separate heaters or coolers, which can be operated as required to suit the prevailing conditions. (Fig. 5, 6 and 7 illustrate air conditioning units installed on a passenger vehicle.)

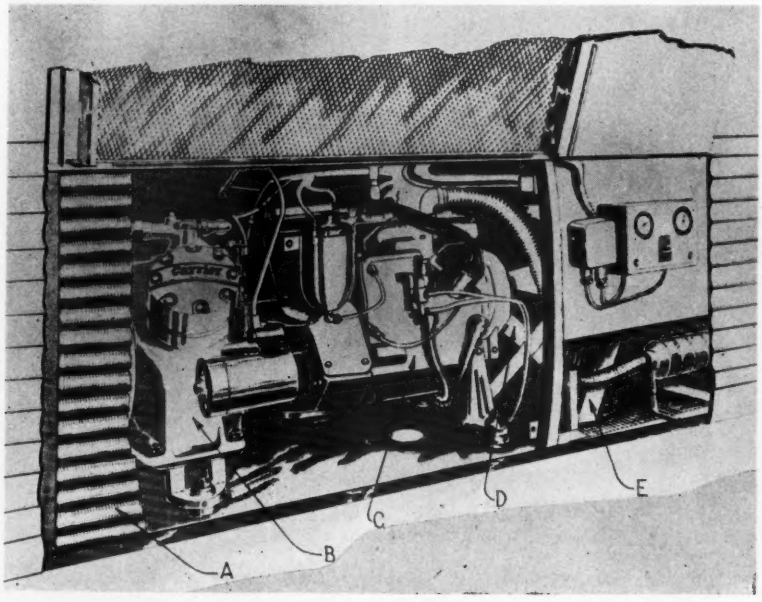


Fig. 7. Air conditioning installation in the side of a vehicle
A. Condenser. B. Compressor. C. Engine. D. Cooling fan. E. Radiator.

(*To be continued*)

INDUCTION HEATING

Developments in Ferranti-Wild-Barfield Equipment

INDUCTION heating equipment generally comprises two main units, namely, the apparatus for producing electricity supply at frequencies higher than those of the mains supply, and the machine or other equipment whereby this high frequency power is applied to the component to be heated. The generators may be of various forms. Usually, they are either of the rotary machine type, consisting of a motor and an alternator, or of the valve oscillator type. Rotary machines are used where frequencies up to 10,000 cycles per second are required. Valve oscillators are employed to give radio frequencies ranging from 250 kc. upwards.

Both types have definite fields of application with little overlapping. The lower frequencies are applied where through heating or deep penetration for hardening is required on large components. Radio frequencies are more usually adopted for small components and true surface hardening. It will be appreciated that the handling units for use with the two types of equipment may differ substantially. There are also many variations of such equipment even for one type of generator. These notes are concerned only with machines for applying radio frequency power.

General applications

Induction heating has great potentialities and a very wide range of applications. The types of work for which it is most commonly used are :—

Surface hardening. It is very widely used for hardening plain carbon and low alloy steels.

Local hardening. Many components required to be hardened in certain restricted locations, such as on cams and other wearing parts, but which for satisfactory service need not be heat-treated all over. This is one of the most important applications of induction heating.

Tempering and annealing. These operations may be carried out either locally or on a complete component. On many of these applications induction heating will give large reductions in production costs and times.

Soldering. Experience has shown that on many applications radio frequency gives results that cannot be obtained by any other method. The speed with which the heat is applied melts the solder without overheating the component. This is particularly important when the component has an insert that may be damaged by heat.

Brazing. The remarks concerning soldering apply equally to brazing. In addition, the even flow of silver solder or flux gives economy in materials. Furthermore, joints brazed by radio frequency heating seldom require a subsequent finishing process. Among components that are successfully treated may be mentioned small arms parts, lathe tools and milling cutters.

Through heating. Valve generators can be used successfully for through heating small components, but the generators giving lower frequencies are much more widely used.

Melting. A number of valve sets are in use for induction melting of ferrous and non-ferrous metals for laboratory purposes and for small scale production. Generally, however, motor generator sets are used for melting.

Special purpose and multi-purpose equipment

The method of transferring the energy to the work that is to be heated, the design of the heating coils and the means by which the work is handled are factors of fundamental importance in the application of induction heating. Their establishment to give optimum results depends upon knowledge that can be acquired only through experience in dealing with such problems. Where users not fully conversant with the many factors involved attempt to design their own equipment, the results are likely to be disappointing.

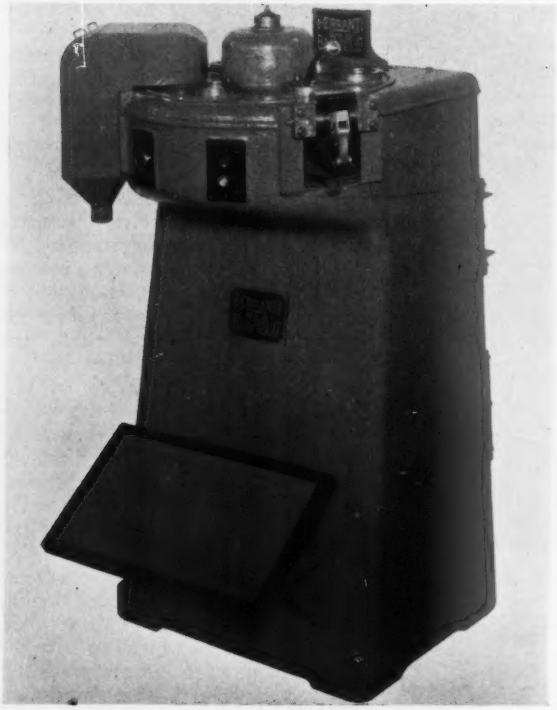


Fig. 1. A single purpose induction heating machine with a six-station rotary table.

Fig. 2. A universal workhead with a single-station easily replaceable jig.

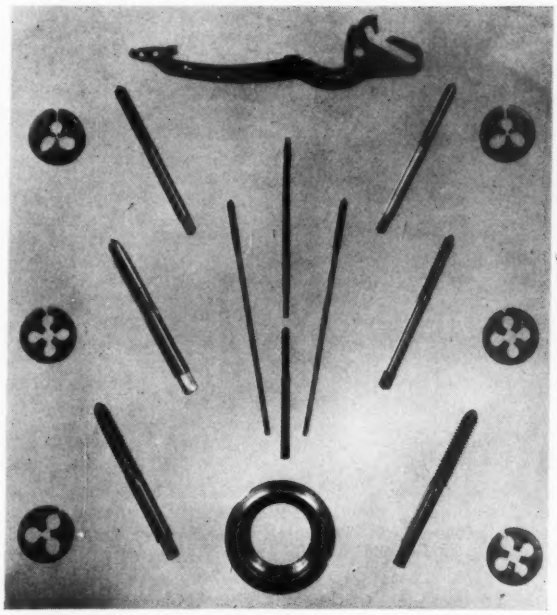


Fig. 3. A selection of small parts hardened by induction heating.

When quantity production is involved, experience has shown that a single-purpose machine has many advantages. As with other machines, a unit designed to cover a wide range of different components must represent a compromise in which efficiency, ease of operation, and the results obtained may all suffer in greater or lesser degree. The more automatically an equipment is designed to operate, the more specialized of purpose does it become. For large scale quantity production, where the need for reducing the cost of each operation is greatest, fully mechanized high-frequency induction heating equipment should be used so that the greatest possible advantages may be obtained.

There are however, many instances in which a single-purpose machine would not be justified. For example, although the components may be produced in considerable quantities, the total output required may be such that the machine would be idle for relatively long periods each day. It must be remembered that the very rapid heating results in high numerical output of parts from one machine. It is obviously uneconomical to have a single-purpose machine in operations for only short periods, particularly if there are other components suitable for induction heating but differing in size and shape. Where this condition exists, semi-automatic operation should be adopted to increase the versatility of the heating units.

The available Ferranti-Wild-Barfield equipments, marketed by Wild-Barfield Electric Furnaces Limited, Watford By-pass, Watford, Herts., range from single purpose, fully-automatic machines, which can be regarded in the light of precision machine tools, to units simple in mechanical design but capable of adaptation to the treatment of varied components and applications. In these notes it is possible to describe only a few of the many types of equipment. So far as single purpose machines are concerned, they are invariably designed specifically for each application according to the purpose, nature of the component, production output and all other relevant factors.

A typical example of a machine designed for only one operation is the soldering machine shown in Fig. 1. This is used in a works where the output warrants the installation of machines designed to deal solely with one type of component, and therefore working as nearly as possible under ideal conditions. Conditions involving machines suitable for handling a variety of components are, probably, more frequently encountered. One of these machines is shown in Fig. 2, and a selection of tools and parts heat-treated on it is shown in Fig. 3.

All machines have certain important features to safeguard personnel and equipment. For example, on the Ferranti-Wild-Barfield models the inlet for connection to mains water supply at 35/60 lb. per sq. in. for cooling purposes is fitted with renewable filters to prevent the introduction of foreign matter into the copper tube windings of the output transformers and heating inductors. Furthermore, protection against operation of this equipment should the water supply fail or drop to an inadequate figure is provided by one or more pressure or flow switches.

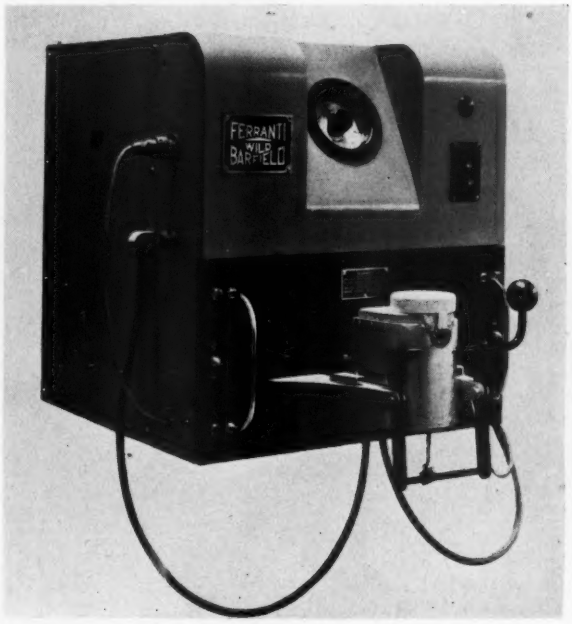


Fig. 4. A universal workhead with crucible for melting precious metals.

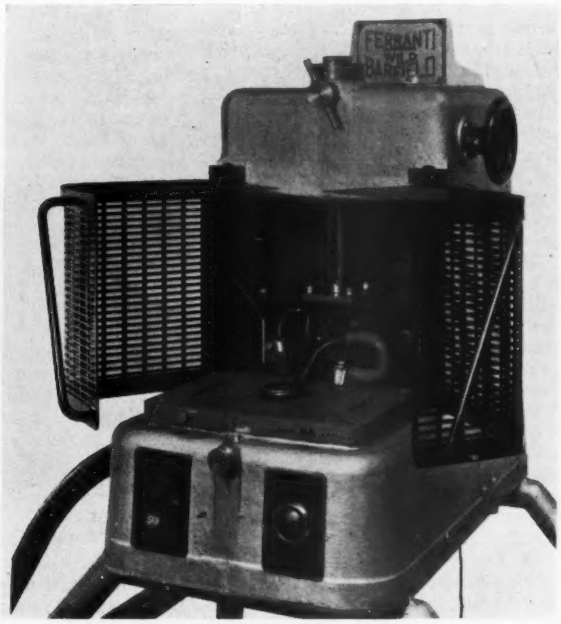


Fig. 5. A workhead for local or surface hardening and fitted with safety guards.

Most Ferranti-Wild-Barfield machines also incorporate output transformers to feed the heating inductors. In such cases, only low voltage is applied to the heating inductors, which are therefore safe even when exposed. In certain machines, where output transformers are not included, the heating inductor is enclosed and cannot be touched until the high frequency power has been switched off. Interlock switches on heating inductor enclosures and on readily removable panels render safe all parts working at high voltage before access can be gained to them. In addition, adequate screening is provided to prevent interference with radio communications.

Universal workhead

A universal workhead has been developed to cover a very wide range of applications. It can be supplied as a floor mounting unit on a tubular framework stand as shown in Fig. 2 or as a bench mounting model as shown in Fig. 4. The model shown in Fig. 4 is also supplied for mounting over a quench tank, and where alternative quenching media are necessary to allow treatments to be carried out on steels of different analyses, the complete workhead is mounted on a carriage on rails fitted to the top of a quench tank with two compartments, one containing water and the other oil.

While in some applications the workhead is incorporated in some of the special purpose machines, its main function is to be used with multi-purpose machines. For this reason it incorporates interchangeable jig panels, each of which can be supplied initially, or subsequently at relatively low cost, to deal with one or more components. The workhead itself, enclosed in a screened housing, incorporates the latest type air-spaced, water-cooled output transformer. The feeder from the output transformer engages with the applicator on the jig through a clamping device. Inside the workhead cubicle are water filters, water-controlled switches and other protective devices for the safety of personnel and equipment. A terminal strip provides easy means for connection to the radio frequency valve generator that serves the unit.

All water cooling tubes, which must be of a prescribed minimum length for satisfactory operation, are coiled and cleated inside the housing. They are connected at their ends by means of screwed unions. Process timers are usually required to control the duration of the heating cycle, and in many cases to control the operation of the quenching or other devices on the jig. Therefore, when necessary, a process timer of suitable range is fitted. It can be set to any desired time cycle within its range.

In the main the workhead is a standard unit, but the jig panels are very varied. All, however, are completely interchangeable and on Ferranti-Wild-Barfield equipment any jig can be fitted to the workhead. The jig itself comprises a panel attached to the workhead frame by four bolts and accurately registered in position by substantial dowels. Fitted on the panel are the sockets to receive the control circuit plugs and a heating inductor and work locating fixture designed to suit the particular component for which the jig is to be used.

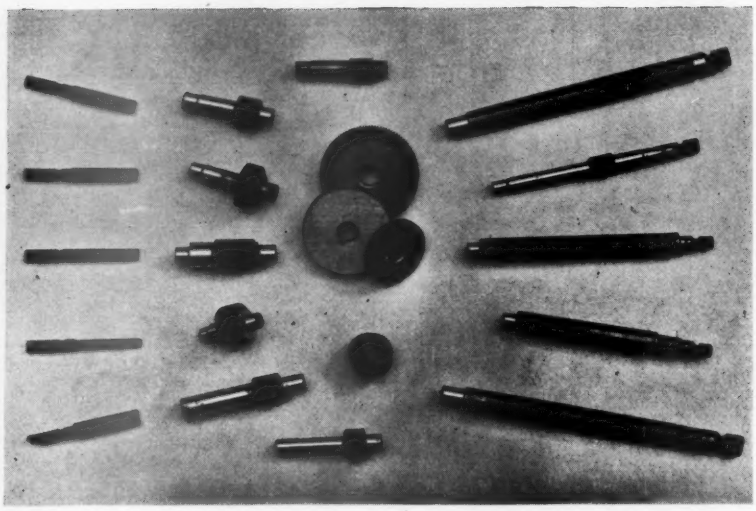


Fig. 6. Gears, pinion and shafts surface and local hardened and tempered on the workhead shown in Fig. 5.

One of the most important advantages of the jig system is that the heating inductor and work locating fixture are both fitted to the jig. They are therefore always in a fixed relation to each other, and the interchange of complete jigs leaves the heating inductor and the work locating unit undisturbed. Change-over is easily effected. A simple clamping device that connects the heating inductor to the feeder from the output transformer is released and the flexible water connections to the heating inductor and the control circuit plugs are removed. The complete panel can then be detached from the workhead frame and stored away ready for immediate use when next it is required.

Surface and local hardening

For many surface or local hardening applications, induction heating has many advantages over all other methods. The universal workhead described above is widely used for these treatments. For some components however, ease of operation can be increased by the use of machines such as that shown in Fig. 5. This is not universal to the same degree since it cannot be used conveniently as a production tool for hardening, brazing and melting. On the other hand, it is by no means a single purpose machine as is shown by its performance in a factory where portable electric tools are manufactured.

In the production of these tools

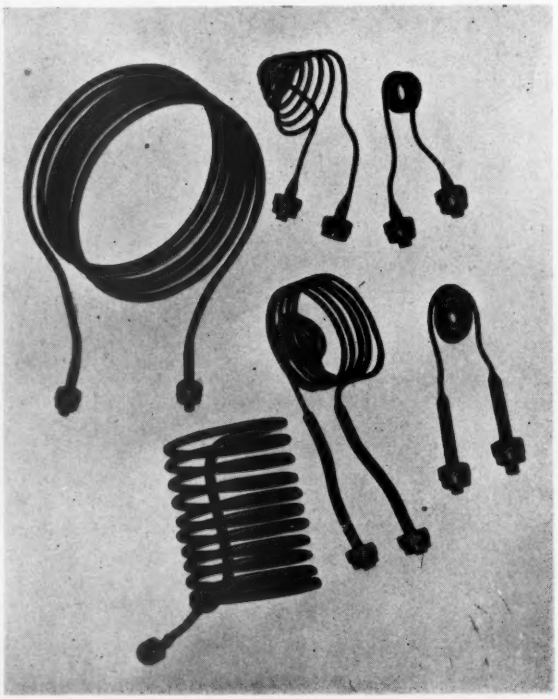


Fig. 7. Work coils specifically designed for individual components.

there are many gears, pinions and shafts that require heat-treatment and for which surface and local hardening and tempering are carried out by induction heating. Some sixty or seventy different components are successfully treated in one machine. They vary from $\frac{1}{4}$ in. diameter armature shafts and $\frac{5}{8}$ in. diameter pinions to 3 in. diameter gears. Other parts up to $8\frac{1}{2}$ in. long are conveniently handled by the use of accessories that can readily be fitted. Heating times range from one to ten seconds for surface hardening operations. The core properties are not affected in any way. In addition, as only the teeth of the gears are heated and quenched, the desired results are obtained with a minimum degree of distortion, so that the need for corrective grinding is in large measure avoided. Some of the parts treated are illustrated in Fig. 6.

An output transformer, to which the heating inductor is connected, is housed in the main body of the machine behind the work table. The whole unit is mounted on a stand that incorporates a quenching tank. The worktable comprises a heat-resisting insulated plate with a rectangular aperture into which a pair of combined work-locating jigs and quenching flaps are fitted. Although the design of the heating inductor varies considerably according to the shape and size of the component and the mechanical properties required, all heating inductors are interchangeable. Just as the majority of individual components require their appropriate jigs and flaps, so, in general, a separate work coil is required for each part. A selection of work coils is shown in Fig. 7.

To obtain true surface hardening, a high power input per unit area is necessary to raise the surface temperature sufficiently rapidly to prevent deep penetration. On large components this would involve the use of a radio frequency generator of very high power output. The speed of heating, and therefore the rate of production in such circumstances would usually be far too great for production requirements, and the equipment would be idle for long periods. To overcome this and to allow the use of generators of lower input and lower capital cost, progressive heating, as opposed to "single-shot" heating can be adopted. In the progressive method the power is applied at any instant to a relatively small area. This allows the application of the correct power per unit area. The work is progressed at a continuous speed through or adjacent to the heating inductor and is quenched continuously immediately it reaches the specified temperature.

This method is particularly suitable for components such as gudgeon pins and shafts and other objects of uniform section. Its value increases as the periphery of the part becomes greater. A Ferranti-Wild-Barfield machine for this purpose is shown in Fig. 8. The same method, using a heating inductor of special form, is used for hardening hacksaw blades and for continuous hardening and tempering of steel strip. In the case of hacksaw blades, the treatment can be arranged to produce hard teeth and a soft back or to harden the two edges and leave the centre soft. Progressive heating does not always involve progression of the work itself. In some applications, such as hardening the teeth of large gears or in surface hardening large flat areas, the heating inductor, specially designed for the purpose, is progressed and "scans" the surface to be heated.

Brazing

Many components at present machined from the solid could be produced more cheaply if they were redesigned for brazing or silver soldering. Used in conjunction with controlled atmosphere furnaces, this technique has been thoroughly proved and is now established practice for many parts, but there are many parts that for one reason or another cannot be furnace brazed. For such components it is well worth while to consider the possibility of using induction heating. There are, for example, many parts that can be safely heated at the joint, but which could not withstand the temperature if it were maintained too long. For such parts radio frequency heating may be particularly suited, since the speed of heating is such that the heat can be localised to the area to be brazed. It can also lead to increased production at lower unit cost. In addition, induction heating ensures an even flow of flux or solder with resulting economy in material, and furthermore joints so made seldom require a subsequent dressing operation.

A manually-loaded brazing machine is illustrated in Fig. 9. It has three simultaneously operating brazing stations for silver soldering a wide variety of components. The use of a multi-station permits the highest possible load factor on the high-frequency

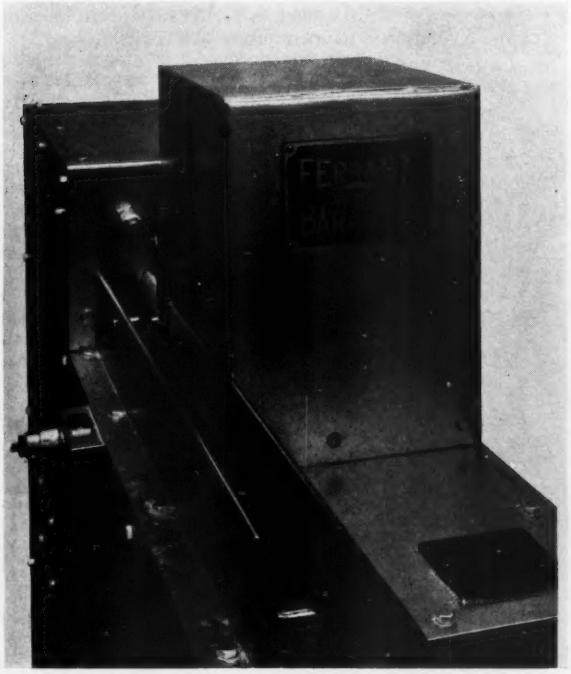


Fig. 8. An automatic special-purpose induction heating machine. Quenching is effected by the jet above the work coil.

Fig. 9. A triple-station induction brazing machine fitted with a process timer and pedal operation.

valve generator. A process timer is fitted to this machine. This simplifies operations for, having loaded the component into position and started the process by foot switch or press button, the operator is free to prepare further components while the process timer stops the heating at the predetermined time and automatically re-sets itself for the next cycle.

Soldering

Machines that give accuracy of repetition and close control in soldering operations are illustrated in Figs. 1 and 10. The machine shown in Fig. 10 is designed to solder mild steel pressings to close tolerances. Furthermore, it is capable of dealing with a considerable range of different types and sizes of work. In the application illustrated, it delivered components at the rate of 10 per minute. Both machines are designed to operate on the indexing principle, through a Geneva star movement that rotates a platform in 60 deg. steps. Machine tool practice is followed throughout the design of these machines.

The importance of the fit tolerances on components that are to be soldered must be stressed. Dimensional uniformity within close limits is usually necessary in application of induction heating, but it is of primary importance where steel-to-steel or steel-to-brass or copper joints are to be made. The maximum clearance between components should not exceed 0.005 in. in the case of similar materials, and the smaller the clearance the better will the results be. Variations in fit and in external dimensions must necessarily cause differences in the rate of heating and heat transfer, and as, in the majority of machines, control of temperature is effected by a fixed time cycle, variations in the rate of heating will lead to over or under heating and consequent unsatisfactory joints.

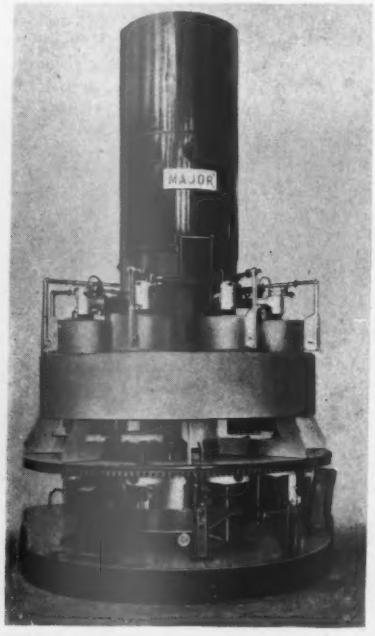
Fig. 10. Ferranti-Wild-Barfield equipment for soldering pressings to hexagon nuts.

WHEEL MANUFACTURE

An Australian Furnace for Heating Blanks

A NOVEL oil-fired rotary furnace has been developed in Australia for heating to about 1,000 deg. C. the short domed cylinders used in forming wheels for motor trucks. It is shown in the accompanying illustration and was manufactured by Major Furnace Engineers Pty. Ltd., of South Melbourne. The cylinders consists of $\frac{5}{16}$ in. steel and are 13 in. diameter by 10 in. high with a domed head having a central 5 in. diameter hole. They are heated on the domed head and 1 in. down the cylindrical sides. Heating is effected by lifting each cylinder on a refractory dolly up to the mouth of a high-temperature combustion chamber, where the radiation from the walls of the chamber and close contact with the high velocity products of combustion discharging through the annular space between the work and the combustion chamber produce very rapid localised heating.

Eight combustion chambers are mounted on a rotating table. A dolly is located beneath each chamber and is spring-lifted to the mouth of the chamber. At one point in the rotation of the table, a cam withdraws the dolly until it is flush with the surface of the table to form a loading and unloading station. A withdrawn dolly can be seen to the right of centre in the illustration. The table rotates in a clockwise direction and in the course of one revolution the work is brought up to the pressing temperature of about 1,000 deg. C. A variable speed drive is fitted to the table. It allows the time per revolution to be between one and three minutes to give outputs from 480 to 160 per hour.



Major oil-fired rotary furnace.

Each combustion chamber is independently fired by a "Uni" oil burner with single lever control for both air and oil. Correct proportioning of air and fuel is effected by movement of the lever from high to low position. Air for combustion and atomizing is supplied at 12 in. water-gauge pressure. A simple cam-and-roller mechanism turns the burner to low-firing position at the unloading station to give the best possible conditions for the operator. The oil storage tank, electric motor and pump, combustion and atomizing air blower with its accompanying motor, table driving motor and reduction gear, and switchboard and control panel are all mounted on the main framework. As a result, the furnace is a complete transportable unit that merely requires connection to an electric supply to be ready for operation. The central stack houses a large propeller fan which not only evacuates the products of combustion from the eight burners and their respective chambers, but also draws in a large volume of cooling air over the rotating table.

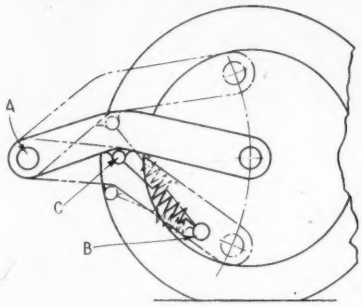
CURRENT PATENTS

A Comprehensive Review of Recent Automobile Specifications

Vehicle suspension

IT has in the past been fairly common practice, mainly on heavy commercial vehicles, to provide what is in effect a plurality of springs, usually semi-elliptic, to give a variable rate suspension. One of the objects is to give a reasonable ride under light, as well as heavy, load conditions. This patent is a device to obtain the same effect from a single coil spring suspension unit.

By virtue of the geometry of the spring and link system the effective suspension rate is made proportional to the load carried. Under a heavy load the points A and B, being on the frame, sink and the line of action of the tension spring approaches the tangent to the circular path of C. The suspension rate then nearly equals the spring rate. Conversely, under light load the points A and B are higher, with the result that the line of action of the spring approaches the line joining C



No. 644851

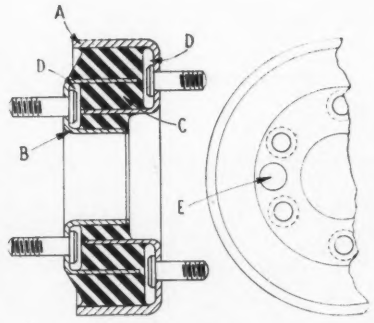
with its centre of rotation A, giving rise to a light effective suspension rate.

In the specification certain recommendations are made regarding the relative proportions of the dimensions between A and B, and between A and C, as well as for the proportions of the spring and the angular travel of the links. It is also stated that by suitable re-arrangement of the system, a compression spring may be used instead of the tension spring shown in the diagram. *Patent No.* 644851. *J. A. Gregoire (France).*

Resilient couplings

A COUPLING suitable for power transmission, employing annular, concentric driving and driven members, disposed to form not less than three annular spaces occupied by rubber or like material bonded to members, was the subject of an earlier specification.

It has been found that distortion and breakdown of the couplings can be reduced by spacing the rubber from the radial walls forming the ends of annular members to permit deformation of the rubber under load or misalignment. An improved coupling therefore incorporates an air space. In assembly, driving and driven members A and B, treated to permit bonding, are correctly juxtapositioned, and a vulcanizable rubber composition is moulded into annular spaces C. The assembly is heated to bring about vulcanization and bonding simultaneously.



No. 644527

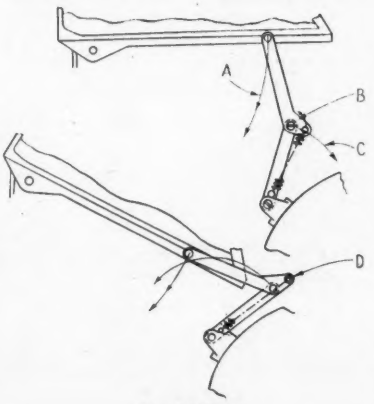
Provision for air cavities D is made by previously casting into place a water-soluble core, access to which is provided by three holes, one of which is shown at E.

The specification provides for the use of more than three annuli and, in general terms, for "resilient deformable material" as well as for soft vulcanized rubber in particular. The members may be of brass, brass-plated steel, or steel coated on the bonding surfaces with a suitable adhesive. *Patent No.* 644527 *Dunlop Rubber Company and H. Wilson.*

Pivoted window

THIS invention relates to a window pivotally mounted adjacent to one of its lower corners so that it can be swung downwards in a vertical or near-vertical plane to be stowed, when in the open position, in the body panelling. A window of this type, with the edge remote from the pivot formed in an arc of a circle whose centre is at the pivot, is suitable for a rear quarter light.

Movement of the window in the direction of arrow A from the closed position causes toggle pivot B to move in the direction of arrow C and extends the spring. When the window approaches the full open position the line of action of the spring coincides with the line joining the two toggle pivots at D, and further movement causes the balancing torque applied by the spring to be reversed in direction



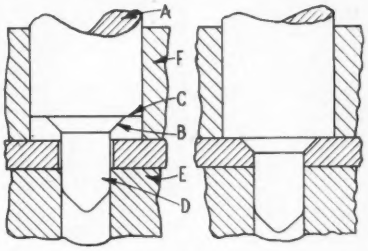
No. 644270

and at the same time to be progressively reduced. Thus the function of the spring in that position is to hold the window firmly open.

It is claimed that the weight of the window is always counterbalanced except, possibly, in the fully open position. This result is obtained by arranging the geometry of the toggle mechanism in such a manner that the positions of the pivots and the stiffness of the spring bear the correct relationship to the torque due to the weight of the window tending to turn it about its pivot. *Patent No.* 644270. *Carbodies Ltd.*

Countersinking sheet metal

FOR forming countersunk apertures in sheet metal more rapidly and with greater uniformity than has been practicable by conventional means, and without the formation of "proud" surface or edges, this method consists essentially in the use of a conventional punch to produce a hole somewhat oversize, followed by a



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coining punch A which produces the required countersunk configuration under pressure. The displacement of marginal metal is controlled by the working face B, lateral shoulder C (preventing formation of upstanding edges), and pilot rod D of the countersinking punch, and by the upper face of the die plate E. The pilot rod has a diameter equal to that desired for the lower portion of the aperture and the diameter of the initial hole is reduced under pressure until the metal grips the pilot rod. Buffer springs may be used to maintain the stripper plate F in contact with the metal being worked, preventing its lifting on the upstroke of the tool; alternatively the stripper plate may be secured to the die.

The apparatus may consist of a holder having a shank fitting in the head of the press, conventional and countersinking punches secured by blocks, preferably to the same holder (or combined in one tool), stripper plate, bolts and helical compression spring or springs, and die plate. The stripper plate may be made to serve the purpose of the shoulder on the countersinking punch.

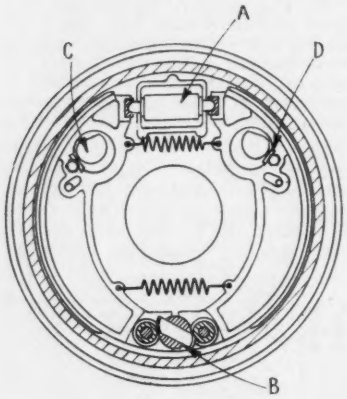
Apertures may be punched out and countersunk by successive strokes of the same press. The method described is suitable for mass production purposes, and the margins of the apertures tend to be hardened and strengthened in the process. *Patent No.* 644963. *S. B. Caldwell and E. Hurley.*

Hydraulic and mechanical brake

HYDRAULIC operation is effected, by any suitable device A, in the manner normally adopted for internally expanding brakes. The fixed point B is formed by the mechanism designed for mechanical operation, and clearance between shoes and drum with the brake off is adjusted by means of the cams C.

When the brake is operated mechanically the mechanism at B is rotated so that the inclined faces, bearing against the rollers mounted on the shoes on each side of B, force the shoe assemblies against the drum. The tendency of the shoes to rotate with the drum forces the inclined elements D, which are also mounted in the shoes, to ride up the surface of the cams causing that end of the shoe assemblies to come into firm contact with the drum. The cams therefore act as fixed abutments for the shoes when mechanical operation is used.

It is claimed that the bearing of the inclined elements against the cams gives



No. 645272

a servo action inasmuch that there is a component of the cam reaction tending to force the shoe against the drum. *Patent No.* 645272. *Regie Nationale des Usines Renault* (*France*).

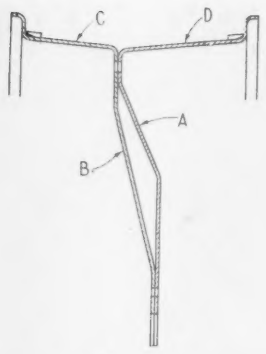
Bending metal tubing

LOADING materials commonly used in the cold bending of metal tubing are all liable to be unsatisfactory in one respect or another. Granular materials permit buckling, tar or lead is difficult to remove, and low melting point alloys are expensive.

It is proposed, therefore, to fill the tube with water and freeze it. Bending is performed in the usual manner; the ice core yielding with slight melting at the fractures so that the crystals move relatively freely. Ammonium chloride, sawdust, cotton-wool or asbestos may be added to the water to reduce the size of the ice crystals. Cost is trifling, in moderate heat or even room temperature the tube will drain and dry, and no subsequent cleansing will be necessary. *Patent No.* 638389. *W. G. Jenkinson Ltd. and H. A. Jenkinson.*

Disc wheels

A DISC wheel for pneumatic tyres is built up of two disc elements supporting, or formed integrally with, a wheel rim. The discs have abutting plane portions near the rim and near the centre, forming seating faces at which the two



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elements may be joined by bolts, rivets or welding. Their conical portions A and B face in the same direction but have different cone angles to give high moment of inertia and, consequently, high resistance to lateral and other forces.

The rim may be in two parts C and D, each being in one with its disc portion, or it may be in one piece and attached to the periphery of the wheel constituted by the disc elements. The disc portions may be solid, or apertured to form spokes, and it is suggested that light-weight or mechanically weak material may be used. In particular, pressed sheet iron is envisaged. *Patent No.* 645029. *Manufacture de Caoutchouc Michelin* (*France*).

Hollow cast crankshafts

IT has been found desirable to form a crankshaft with hollow journals and pins to reduce critical stresses. Preferably the lightening holes should be barrel-shaped and obviously, in this connection, the cast crankshaft with cored holes offers opportunity to reduce production costs. Unfortunately, if normal cores are used the cooling rate of the inner zones of the holes is not speeded up as, due to the low thermal conductivity of the core material, the outer zones of the core rapidly attain the temperature of the molten metal. This yields a weakened internal structure and a reduction of strength in comparison with a solid shaft.

It is proposed, therefore, to accelerate the distribution of heat from the shaft centre by the use of hollow metal cores, which maintain their own properties without contamination or embrittlement during the casting process and serve as reinforcements in the finished product. The core shells may be made by any convenient method from sheet, tube or cast stock and may be rough machined, ribbed or corrugated on the outer surface to ensure effective attachment. Untreated mild steel is unsuitable for such shells as carbon diffusion leads to embrittlement but mild steel with a coating of copper or nickel is satisfactory. In thickness the shell should not exceed one-sixth of the adjacent cast section. They are made longer than is necessary for the finished article. In the mould the protruding ends serve as prints and subsequently are machined off.

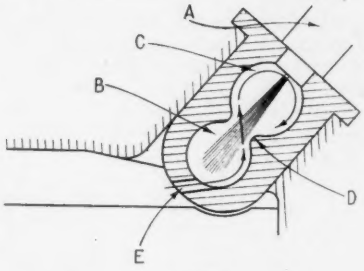
To adjust the rate of cooling to the desired value the shell may be used plain, as A, fitted with a fusible metal liner, as B, filled with granulated material, as C, or a solid cast material, as D. A sump is provided in the sand of the mould to receive the filling as it runs out of the shell.

The drawing shows a section of a shaft with hollow journals and pins and a four-throw shaft with cored bearings and webs. *Patent No.* 644841. *J. G. Fife* (*Meehanite Metal Corp. U.S.A.*).

Diesel engine precombustion chamber

IN view of the trend towards direct injection to secure maximum fuel economy, this cross-flow precombustion chamber is of interest. Apparently the primary aim is to ensure smooth operation.

Mounted in the cylinder head at an acute angle to the cylinder axis, the chamber



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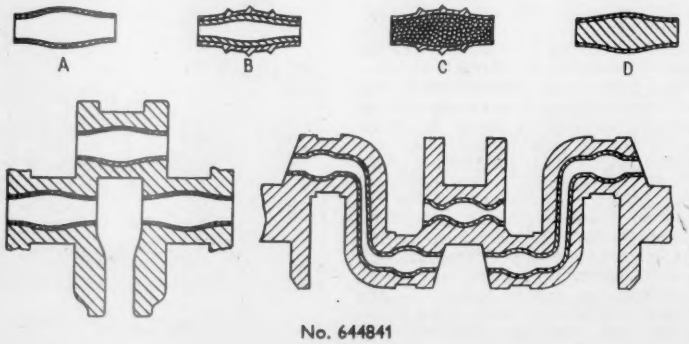
supports the injector A arranged on, or parallel to, its axis. The volume of the chamber is constituted by lower and upper spheres B and C communicating by way of a venturi-like constriction at D. Combustion air from the engine cylinder enters sphere B by one or more tangential orifices E, and is deflected at constriction D to the opposite wall of sphere C to describe an S-shaped path.

It is claimed that ignition is initiated in sphere C, fuel is swept into sphere B and thence ejected into the cylinder. The combustion gases leaving the chamber are directed substantially parallel to the surfaces of the piston crown and cylinder head and thus local overheating is avoided. *Patent No.* 645221. *Steyr-Diamler-Puch AG.* (*Austria*).



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